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# ECHINOCOCCOSIS ALVEOLARIS (ALVEOLAR HYDATID DISEASE), ASSOCIATED WITH ORDINARY HYDATID CYSTS OF THE LIVER.[1]

By J. A. MEADE,

*Assistant to Professor E. F. D'Ath, Department of Pathology, University of Otago,*

AND

SIR LOUIS BARNETT,

*Emeritus Professor of Surgery, University of Otago.*

THIS article deals with *echinococcosis alveolaris* or alveolar hydatid disease, and records a case of this condition that was associated with ordinary hydatid cysts of the liver. The case is the first in New Zealand to be reported. The patient was operated on by Mr. J. A. Jenkins, F.R.A.C.S., at the Dunedin Hospital on February 9, 1940.

In common with other sheep-grazing countries of the world, New Zealand suffers from a high incidence of hydatid disease. In the last fifty years just about 3,600 cases have been listed (Barnett, *New Zealand Medical Journal*, December, 1940). These cases have, with the single exception now recorded, all conformed to the classical type, presenting one or more cysts each with its host's defensive fibrocellular pericyst or adventitia, its laminated hyaline ectocyst and its nucleated, protoplasmic endocyst or germinal membrane giving rise to the reproductive elements—the brood capsules, scolices and maybe daughter cysts. It is now of considerable interest to be able to place on record for the first time in New Zealand a case of hydatid disease differing markedly in many features from the ordinary type and conforming to the classification *echinococcosis alveolaris*.

## CASE HISTORY.

(J. A. Meade.)

The patient was first admitted to the Dunedin Hospital in September, 1928, and her condition was regarded as a medical and not a surgical one. She was then aged

[1] Accepted for publication on October 29, 1940.

fifty-nine years, a married woman with no children. Although partly of Spanish origin, she was born in Dunedin and except for a very brief visit to Melbourne many years previously, she had never been away from New Zealand. There was a history of typhoid fever and of pleurisy some forty years previously, but generally speaking she had enjoyed good health for most of her life. She complained of shortness of breath, sweating of the feet and palpitation during the past three months and of epigastric pain (absent at rest and unrelated to the taking of food) for two weeks. On examination she was found to have a high tension pulse and a systolic blood pressure of 212 and a diastolic pressure of 175 millimetres of mercury. Her liver was grossly enlarged, extending six inches (15 centimetres) below the costal margin; it had a smooth lower border. The enlargement appeared uniform, and the left lobe was palpable as well as the right. The hydatid complement fixation, the Wassermann and

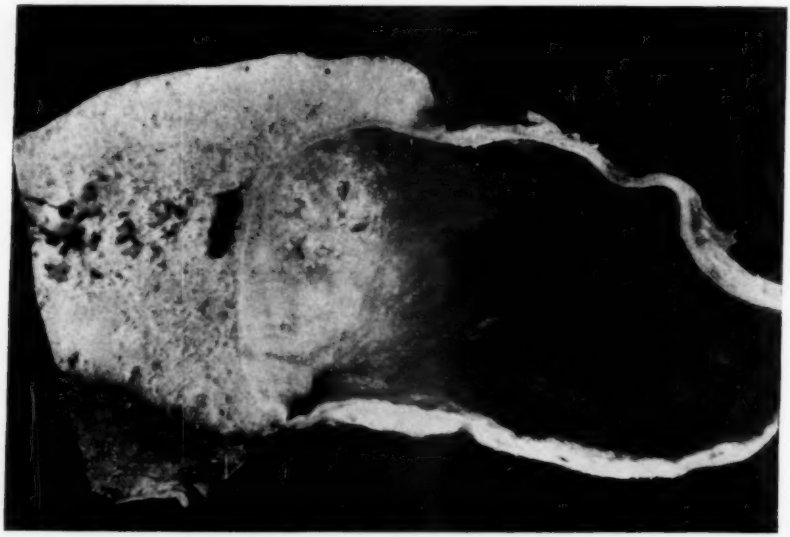

FIGURE II. Photograph of transverse section. Note the contrast between the two types of lesion.

the Kahn tests were all performed, and in each case the result was negative. She was treated as a hypertensive patient with myocardial failure and was relieved by rest. There followed a long period of moderately good health and activity.

In January, 1940, at the age of seventy-one years, she was readmitted to Dunedin Hospital, this time with a diagnosis of a surgical condition. For the previous six months she had been attending the out-patient department from time to time and had been treated for her cardiac condition. The liver enlargement was thought to be cirrhotic in nature.

She now complained of lassitude, gradual loss of weight, and of a tumour in the left side of the abdomen which "dragged her down". There had been little digestive disturbance and no jaundice nor ascites. On examination the cardiac signs were as before. The abdomen presented a hard swelling in the epigastrium, projecting down below the umbilicus. Both the hydatid complement and Casoni tests gave negative results. Radiological examination revealed elevation and decreased movement of the left dome of the diaphragm, with some irregularity of outline of the right dome. The stomach was displaced as by extrinsic pressure, probably from a mass in the liver. The chest was clear. A provisional diagnosis of secondary carcinoma of the liver was made, but in order to clear up uncertainty it was decided to perform an exploratory laparotomy.

The operation was carried out under local anæsthesia on February 9, 1940, the surgeon being Mr. J. A. Jenkins and the assistant his house surgeon, Dr. I. M. Rutherford. When the abdomen was opened there was noted bulging from the left lobe of the liver an old-looking cyst the size of a large grape fruit, with thick dense fibrosed adventitia and yellowish mushy gelatinous marmalade-like contents suggestive of degenerated hydatid material. This cyst was evacuated, marsupialized and drained.

FIGURE III. Photograph of vertical antero-posterior section through right lobe. Note the alveolaris microvesicular structure with beginning central cavitation and compare with the cysts of ordinary type.

Occupying the right lobe of the liver was a hard finely nodulated mass, yellowish-grey in colour and about the size of a coconut, which, although suggestive of carcinoma, was thought by Mr. Jenkins to be possibly some unusual manifestation of the hydatid infection. A small piece of this suspicious mass was accordingly removed for biopsy, then the wounds were sutured and the patient was returned to bed. Pathological examination of the contents of the large cyst revealed typical hydatid material, while sections of the biopsy specimen presented numerous small cyst-like spaces surrounded

by fibrosis with foreign body giant cells and an inflammatory cell infiltration. After the operation the patient's condition was moderately good for a few days, but she then went rapidly downhill, became comatose on the eighth day with left hemiplegia, and died on the tenth day after operation.

### *Post-Mortem Findings.*

The post-mortem report, dated February 20, 1940, is as follows:

"The body is that of a dark-skinned, obese, elderly woman. The abdomen presents a recent right paramedian operation incision. Both lungs show hypostatic congestion and both pleural cavities contain a moderate quantity of straw-coloured and slightly turbid fluid. In the peritoneal cavity the omentum is bound down in the right iliac fossa and in the right upper abdominal quadrant. There is no ascites and no jaundice.

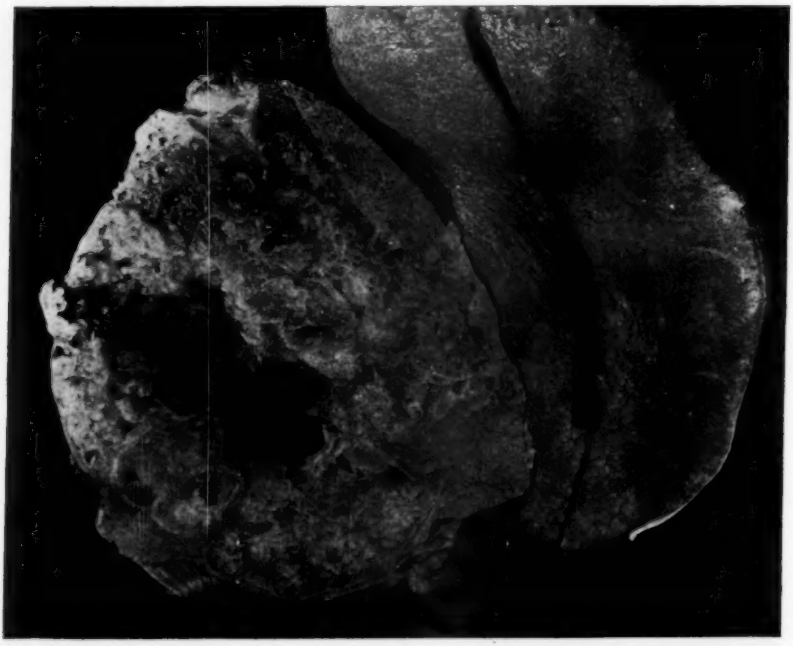

FIGURE IV. For comparison: photograph of a similar section in the unique Uruguayan case, with acknowledgements to Dr. Blanco, Dr. Capurro and Dr. Dévé.

"The kidneys show nephrosclerosis and much congestion. The myocardium is in fair condition; the valves are normal; the aorta is atheromatous. The liver is enlarged, weighing sixty ounces (nearly two kilograms). The left lobe has been replaced by an old ordinary hydatid cyst the size of a grape fruit, thick-walled and obviously degenerated, which had been marsupialized to the upper limit of the abdominal incision. Immediately to the right of the cyst, occupying a considerable part of the right lobe of the liver and adherent to the diaphragm above, there is a hard finely nodulated, yellowish-grey mass about the bulk of a medium coconut (see Figure I). Section of this mass resembles to the naked eye a slice of stale bread, fine sponge or pumice stone. In the centre is an irregular cavity the size of a small walnut kernel, due no doubt to necrotic liquefaction (see Figures II, III and IV). The microscope reveals a con-

glomeration of vesicles varying in size from small shot to pepper corns containing imperfectly developed crumpled laminated membrane (see Figures V, VI, VII and VIII).

"The stroma appears acellular and colloid in nature. The microvesicles are infiltrating or irregularly invading the intact liver substances of the right lobe; in places islands of liver tissue have been isolated by this infiltration. A zone of reaction in the liver tissue contiguous to the microvesicles is recognizable. In this zone one sees a dense inflammatory cell reaction, chiefly polymorphonuclear with also many giant cells. Fibroblasts too are in evidence and extend into the septa between the cysts. No scolices or hooklets can be distinguished anywhere.

FIGURE V. Photomicrograph × 30. Note alveolaris cysts, many showing infiltrating diverticula. Note also surrounding zones of fibroblastic reaction extending into liver tissue.

"Besides the large cyst of the left lobe, there are several other smaller cysts of the ordinary type in the neighbourhood of the alveolar mass, and all of these have a well-marked adventitial envelope which shows no sign of infiltration" (see Figure III).

These pathological findings are closely in accord with those noted in the alveolaris cases described by Posselt, Dévé, Dew and others (see bibliography). Section of the intact part of the liver shows marked fatty degeneration, but no amyloid change.

The other organs were all normal enough, and there was no evidence of metastatic invasion anywhere, although in deference to the husband's wishes the brain was not examined.

## DISCUSSION.

### (Sir Louis Barnett.)

This case, unique so far in the New Zealand records of hydatid disease, adds one more to the small but growing list of sporadic instances of alveolaris lesions in countries previously supposed to be exempt from this particular visitation. As in most of the other sporadic examples, both types, the ordinary cystic and the alveolar, were combined in the same patient.

From the writings of Rudolf Virchow dating back to

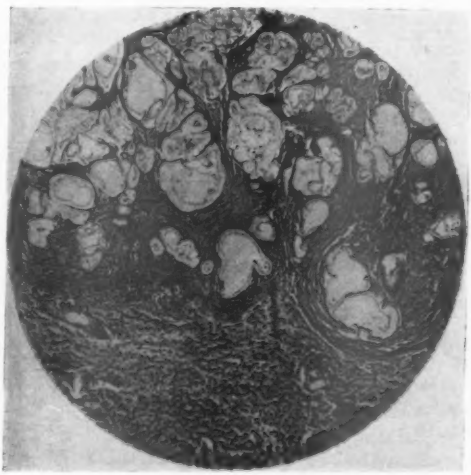

FIGURE VI. Photomicrograph × 30. Note also surrounding zones of fibroblastic reaction extending into liver tissue.

1855 and from the work of Adolf Posselt, of Innsbruck, and others more recently, we have learned of the endemic occurrence of a malignant form of hydatid disease, *echinococcosis alveolaris*, in Southern Germany, Switzerland and the adjacent Tyrol, and of its absence in other parts of the world including those where hydatid cysts of the ordinary type are quite common. This remarkable geographical predilection, amounting almost to mutual antagonism, together with certain other characteristics to which I shall refer later, naturally gave rise to the idea that there must be two different species of the *Tænia echinococcus*, the common kind, widespread throughout the world, and the alveolaris variety, found only in the Bavaro-Tyrolean region.

FIGURE VII. Photomicrograph × 60. Note also surrounding zones of fibroblastic reaction extending into liver tissue.

But as the years went by it became evident that this geographical limitation of the *Tænia alveolaris* was by no means absolute. Another endemic focus was located in Kazan, and sporadic appearances were noted in Northern Germany, France, Moscow, Tomsk, Irkutsk, the Caucasus, Argentina, Uruguay, Australia, and now New Zealand.

The peculiar naked-eye and microscopic anatomy of the alveolaris lesion, its malignant properties, including spread by infiltration to neighbouring tissues, and even by metastases to glands and distant parts of the body, and its striking geographical limitation have naturally suggested specificity in the causative parasite. The supporters of this theory, led by Posselt, became known as the dualists, and opposed to them has arisen a body known as the unicists, who claim that there is only one species of the *Tænia echinococcus*, and that

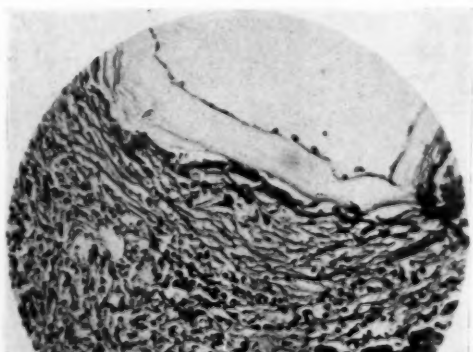

FIGURE VIII. Photomicrograph × 60. Note also surrounding zones of fibroblastic reaction extending into liver tissue.

the peculiar lesions of the alveolar type are mere mutations. For half a century or more ardent controversy has gone on between these opposing camps and the end is not yet. On the whole, with the march of time the unicists seem to be in the ascendancy, especially since the death in 1936 of the dualist champion Posselt, and since the renowned Dévé left the dualist camp and joined forces with the unicists. A definite settlement of the controversy cannot be expected until unassailable experimental proofs are forthcoming, and extraordinary difficulties have to be faced.

A dog suitably prepared has to be fed on human liver freshly removed at autopsy from an alveolaris patient; then after two months, say, ova or tæniæ from this dog's intestine are administered to a suitable intermediate host, say, a young pig, which six months later is killed and examined for an alveolaris lesion. That sounds fairly feasible, but in practice the proposition bristles with difficulties.

The diagnosis in the human subject is usually an autopsy surprise, so no suitably prepared worm-free dogs may be at hand. No other intermediate host except the human one is at present known to us, though cattle are under suspicion.

The alveolar mass is usually (though not invariably) devoid of scolices and consequently sterile. Only about one-third of all dogs seem susceptible to any kind of echinococcus infection.

Hence it is that feeding experiments have so often failed, and actually up to the present time only three or four workers, starting with Mangold and Posselt in 1892, have ventured to claim experimental success, and have demonstrated the alleged specific worm. Posselt, almost a fanatic on the dualist idea, went so far as to declare that the hooklets of the *Tænia alveolaris* are always more slender in build and less curved than in the ordinary hydatid tænia, and that the ova in the mature proglottis are gathered in a rounded clump at the proximal end of the segment instead of being spread through the uterine ramifications. These peculiarities (and a few others) and the geographical limitation of the parasite convinced him and his stalwart supporters without a shadow of doubt that there are two absolutely distinct types of the hydatid parasite. Other research workers, however, headed by Dévé, have not been similarly convinced. They found similar morphological variations in the hooklets and ova of the ordinary tænia and they also claim that the geographical limitation is far from being absolute. And so the little battle between the dualists and the unicists goes on and on.

Professor Harold Dew, of Sydney, reported in THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY for September, 1931, the one and only alveolaris case so far recognized in Australia. His admirable and well documented monograph, with its thirty-five bibliographical references, contains a wealth of information, historical, pathological, clinical and controversial, brought up to the date of publication. I commend it to all students of this interesting subject. Dew, I may say, is a staunch unicist.

I shall confine my own remarks to the developments in the controversy that have arisen in the course of more recent years since Dew's paper appeared and attracted world-wide attention.

All who delve to any degree in the literature of hydatid disease cannot fail to be impressed with the quantity and quality of the work of Félix Dévé, of Rouen. He is *facile princeps* in the domain of hydatid research, and a grateful tribute to him is published in THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY of January, 1935.

Dew, knowing the value of Dévé's opinion, sent the famous professor full clinical details of his unique Australian case, accompanied by pathological specimens. Dévé responded with a meticulous study of the case and with approval of Dew's diagnosis and most of his conclusions. When the New Zealand case was brought under my notice immediately after the autopsy, I agreed with my surgery and pathology colleagues that it was almost certainly a new and precious example of the alveolaris form of hydatid disease combined with cysts of the ordinary type, and similar arrangements for communicating with Dévé were made. Protocols, photographs and liberal portions of the pathological material hermetically packed were promptly posted to him at Rouen. But Rouen, alas, shortly afterwards, came under the savage fury of German bombardment and no doubt Dévé and his laboratory must have suffered more or less in this ruthless onslaught. Months have passed and I am sorry to say that I have had not one word from my old friend and regular correspondent, and my last communications have been returned to me marked "undelivered".

I fully realize that such discussion as I can contribute on this unique New Zealand case is sadly diminished in value by lack of comments and criticism from such a world authority as Dévé. Pathological material from this case has also been sent to Professor Dew.

Since the appearance of Dew's paper in 1931 and Dew's book "Hydatid Disease", Sydney, 1928, I have had the opportunity (thanks largely to Dévé) of studying the following publications which deal in the main with new sporadic occurrences of the alveolaris form of hydatid lesion.

1. A. Posselt (Innsbruck): *"Die Echinokokken Krankheit"* (Hydatid Disease), *Neue Deutsche Chirurgie,* Volume xl, 1928, Ferdinand Enke, Stuttgart. In this comprehensive work Adolf Posselt, of Innsbruck, champion of the dualists, contributes a monumental monograph of 113 pages on the subject of *echinococcosis alveolaris.* It is freely illustrated and loaded (overloaded indeed) with documentary references and is an exhaustive and, to my mind, exhausting compilation. Posselt bases this work on 67 cases under his own personal care and some 600 others gleaned from the literature.

2. A. Posselt (Innsbruck): *"Es gibt keine Uebergangs oder Zwischenformen zwischen beiden Arten des Blasenwurmes"* (There are no intermediate or transitional forms between the two varieties of the hydatid worm). *Frankfurter Zeitschrift für Pathologie,* Volume xlvii, 1934.

3. F. Dévé: *"Une récente observation Islando-Canadienne venant appuyer la doctrine de l'unité de l'échinococcose", Annales d'anatomie pathologiques,* Volume xvi, Number 1, January, 1939.

The patient was a fisherman who had spent most of his life in Manitoba, but who was born in Iceland. He died in 1935 at the age of fifty-four years after many years of suffering from the effects of suppurating hydatid disease of the liver. He had been under the care of Dr. Elmer James and Dr. William Boyd, of Toronto, and they suspected that part of the trouble at least as revealed at autopsy was of the alveolaris variety. They too sought Dévé's opinion, which, with certain reservations, confirmed their own impressions.

Points of special interest are that this man probably picked up his hydatid infection in Iceland nearly fifty years before his death, and that neither in Iceland nor in Canada has there ever before been recorded any instance of an alveolaris lesion.

4. F. Dévé: *"L'échinococcose alvéolaire humaine en France", La revue de pathologie comparée,* Number 487, April, 1937. In this paper Dévé studied the records of 18 autochthonous French patients, most of them, however, coming from the Swiss border district, who showed evidence of the alveolaris hydatid type of lesion.

5. F. Dévé, R. Piaggio Blanco and F. Garcia-Capurro: *"Échinococcose hépatique maligne micro-polykystique infiltrante. Forme intermédiare entre l'échinococcose hydatique et l'échinococcose alvéolaire", Archives Uruguayos de Medicina, Cirurgia, y Especialidades,* Volume viii, Number 1, January, 1936, and *Bulletin de l'Académie de médecine,* Volume cxiv, Number 39, December, 1935.

These papers describe and discuss the one and only case so far recorded in Uruguay.

The patient, a sheep farmer, aged forty-nine years, had been regarded as suffering from incurable Hanot's enlargement of the liver with jaundice and ascites. Autopsy on April 26, 1935, revealed a microcystic hydatid infiltration of hepatic and other tissues, even an artery being invaded. This case was also submitted to Dévé, who confirmed the post-mortem diagnosis of alveolar echinococcosis.

6. F. Dévé: *"Présentation d'un malade atteint d'échinococcose alvéolaire du foie", au nom des* Drs. C. Deville, J. Duval *et* R. Vinzent (*du* Havre), *La Normandie médicale,* Number 5, May, 1931.

7. F. Dévé: *"Au sujet de la nature de l'échinococcose alvéolaire", Discussion de rapport du* Professeur A. Posselt, III *congrès international de pathologie comparée,* Athens, April, 1936.

8. F. Dévé: *"L'échinococcose alvéolaire", Trente-deux années d'étude de l'échinococcose, Association Médica Argentina.* A course of fifteen lectures on hydatid disease delivered at Buenos Aires, August, 1932. This paper includes a description of the patient under the care of Professors Wernicke and Vinas at Buenos Aires in 1904, regarded as the only authentic Argentina example of *echinococcosis alveolaris.*

9. F. Dévé: *"Formes anatomo-pathologiques intermédiares et formes de passage entre l'échinococcose hydatique et l'échinococcose alvéolaire (Bavaro-tyrolienne) chez homme", Annales d'anatomie pathologique,* Volume x, Number 9, December, 1933. This paper includes a discussion of the cases of Orth, Weichselbaum and Dew.

10. F. Dévé: *"L'échinococcose multiloculaire bovine considerée du point de vue de la pathologie comparée", La prensa médica argentina,* Number 11, September 20, 1932.

11. J. F. Martin (Lyon) and G. Tisseraud (Besançon): *Echinococcus alveolaris* of liver (four new cases) reported by J. I. Roux Berger, *Bulletins et mémoires de la Société nationale de chirurgie,* Volume lviii, 1932.

12. C. Pinto and J. L. de Almeida: *"Echinococcose ou hydatidose humana e animal especialmente no Brasil."* O. Campo, March, 1937, kindly translated from the Portuguese language by Dr. E. W. Bennett, Hydatid Research Officer, Otago Medical School.

### *Conclusion.*

Here finally are some impressions arising from the study of this literature and from discussion of the New Zealand case with my colleagues—Mr. J. A. Jenkins, the surgeon in charge, Professor E. F. D'Ath and Dr. J. A. Meade, of the department of pathology, and Dr. Morris Watt, bacteriologist and microscopist.

It will I think be generally accepted that this case is a genuine specimen of a hydatid lesion of the alveolar type superadded to a long-existing cystic form of the disease.

It is a mixed or transitional form similar to certain other sporadic cases that have been recorded as arising outside the Bavaro-Tyrolean endemic area.

It supports the theory of the unicists that mutations can occur in the ordinary growth of hydatids and that therefore there is no necessity to postulate the existence of two different species of the *Tænia echinococcus*. In other words, the hydatid parasite is pleomorphic, influenced in its modes of development by differences in terrain. Dew supports the theory held by Posselt that cattle, so prone to hydatid infection in the multilocular form, may be the intermediate hosts responsible for the alveolaris mutation. Dévé argues that this idea does not stand investigation.

The microscopic structure of the alveolaris lesion is quite like that of an infiltrating malignant growth sometimes with metastatic extensions to glands and to distant organs, lungs, brain *et cetera*.

The records suggest as a possibility that, to begin with, the patients may harbour for many years hydatid cysts of the ordinary type, and that the alveolaris lesions are superadded as the patients come to middle or old age. This may indicate a malignancy mutation due to the influence of something corresponding to a carcinogenic factor. The absence or poor development of the protective hyaline ectocyst in the infiltrating microvesicles and the consequently unrestrained urge of the germinal membrane or endocyst, to which Dew has called attention, are also suggestive of malignancy.

The alveolaris hydatid grows and expands only by exogenous buddings and extrusions of germinal membrane. Growth, though slow, is unchecked, relentless, fatal. There is never cessation, walling off, obsolescence as sometimes occurs with benign hydatids. The central part of the mass sooner or later undergoes necrosis, liquefaction and cavity formation. This, I think, heralds the end of the patient's life.

Prognosis as regards cure is just about hopeless, though in the absence of metastases, as in the New Zealand case, life may be maintained in fair comfort for a very long time.

### *Diagnosis.*

The true nature of the lesion is revealed as a rule only at autopsy or operation. Erroneous diagnoses include carcinoma, hypertrophic cirrhosis, syphilis, gall-stone obstruction, and ordinary hydatid cysts compressing bile ducts.

It is highly probable that alveolaris hydatids are not quite such rarities as the present meagre tally of records suggests.

Persistent icterus, though absent in the New Zealand case, is a marked feature as a rule (in 80%), and strangely enough it does not seem to affect the patient's general health very much.

### *Treatment.*

It is conceivable that if the alveolar mass was limited and located in an easily approachable part of the liver—for example, the left lobe near the surface—it could be dealt with by radical excision, with fair chance of ameliorating the patient's condition and even with the possible chance of cure. Posselt has recorded such an attempt in 15 cases only out of 575 examples of *echinococcosis alveolaris* whose records he had collected up to the year 1928.

Other surgical interventions such as evacuation and drainage, disinfection by formalin, camphorated ether *et cetera*, have given only temporary amelioration in a few cases.

There is thus but little hope in surgical treatment, and the same can be said in regard to medical measures in our present state of knowledge. Drug treatment, vermifuges, arsenic, diathermy, vaccinotherapy, serotherapy, radiotherapy *et cetera* have all been tried and failed in cases of the ordinary cystic type, and they are not likely to succeed in the alveolar type.

## SUMMARY.

A surgical, pathological and parasitological curiosity in the shape of a case of hydatid disease of the liver showing lesions of the alveolar type is described, illustrated and discussed. This is the first case of its kind recorded in New Zealand and is comparable to the case unique in Australia reported by Professor H. R. Dew in this journal of September, 1931. Reference is made with bibliographic excerpts to the few cases of the alveolaris type that have arisen in countries other than its peculiarly selected endemic home, the Bavaro-Tyrolean district.

Some attention is given to the age-long controversy "dualists *versus* unicists", regarding the vexed question as to whether the alveolaris lesion is due to a specific *Tænia alveolaris* or to a mere modification or mutation of the ordinary *Tænia echinococcus*.

## ACKNOWLEDGEMENTS.

Special thanks are accorded to Professor D'Ath and his staff of the Otago Medical School pathology department (notably Dr. Marcus Fitchett) for the photographic illustrations.

# EXPERIENCES WITH BENIGN INTRACRANIAL TUMOURS.[1]

By I. Douglas Miller,
*Saint Vincent's Hospital, Sydney.*

It is but a little over fifty years since Rickman Godlee operated for the first time successfully on an intracranial tumour. Thirty years ago Horsley was working on intracranial pathology with such thoroughness that there are few conditions which he did not recognize and describe. In later years the school of Harvey Cushing has, by pursuing these researches, shed much light on the life history and classification of tumours, and by the establishment of a meticulous technique put their pre-operative investigation and surgical attack on a footing comparable from a mortality point of view with that of any other field of major surgery. Consequently today we are in a position usually to know before operation not only the site and size of a tumour, but often much of its pathology.

The surgeon who applies himself to the relief of intracranial tumours looks for his greatest reward to the benign tumour. For not alone in benignity and good prognosis does its reward lie, but in the satisfaction of overcoming the extreme difficulties in judgement and attack, which so often offset their innocence.

As we shall see, some of the tumours counteract their innocence by virtue of their position, others by possessing an indispensable function, and others by great technical difficulties associated with their removal. There are, however, a few which, benign as they be pathologically, are also innocent enough in the difficulties they offer to the attacking surgeon.

## Astrocytomata.

As an example of the latter I might quote the cerebellar astrocytoma. This gliomatous tumour, when occurring in the cerebellum, is usually cystic. The tumour presents as a cyst and the activating component is placed within the cyst as a mural nodule. We know, thanks to the work of Cushing, that if we remove or destroy merely this mural nodule, the cyst will not reform. This knowledge makes surgical attack on such tumours often an entirely satisfactory and sometimes not so very difficult procedure. We must remember, however, that the tumour may not present so readily on the posterior surface of the cerebellum, and difficulty may be encountered in bringing it to light.

As an example of a characteristic cerebellar astrocytoma I have taken the following case.

A boy, aged thirteen years, was brought to the London Hospital unable to walk or stand, incontinent of both urine and fæces, inattentive, surly, laconic, difficult to manage, and with rapidly failing vision. His mother stated that about one year previously he had been a normal lad, rather bright at school, a help in the home

[1] Accepted for publication on April 15, 1939.

a boy scout, and a valuable member of the local choir. At first he had complained of headaches and attacks of vomiting. His place at school slipped back, and his interest in other pursuits flagged. He went gradually from bad to worse, with frequent attacks of morning headache and vomiting, and later, about three months previous to his admission to hospital, becoming unsteady in his gait until eventually he was in the condition in which we admitted him.

This is a typical history of a cerebellar astrocytoma. The child is usually in or approaching the second decade, the history is primarily one of headache and vomiting, and the onward march of symptoms is slow.

At operation an astrocytoma bigger than a hen's egg was found presenting in the right cerebellar hemisphere. This was removed. The boy made a rapid recovery, and a few weeks later left hospital apparently normal. (Figure I.)

Difficulties in this type of case may occur first with the diagnosis. The main anxiety is to distinguish these tumours from the medulloblastoma, the other common cerebellar tumour of children, which is so malignant that operation is futile. Characteristically this occurs in younger children, and the history is much more rapid. However, it is often difficult to be quite certain of a pathological diagnosis without performing an exploratory operation. One way out of this difficulty is to try a diagnostic course of deep X-ray therapy, which will usually temporarily alleviate the medulloblastoma, but which has no effect on the astrocytoma.

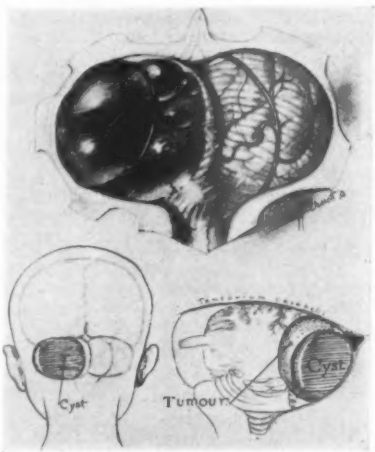


FIGURE I.

When we come to deal with an astrocytoma occurring in the cerebral hemispheres, however, we frequently confront a different problem—a tumour not encapsulated, but diffuse and invasive, innocent only in that if completely removed it will not recur, and in the slow progress of its growth. So slow is the progress that the gradually altering cerebral conditions may long be masked by compensating factors, and when the diagnosis is made the tumour has probably already got beyond the reaches of sane surgical endeavour.

If such a tumour attacks only a frontal lobe or an occipital lobe, or the right temporal lobe, it may be completely extirpated by amputation of this part of the brain; but if, as so often happens, it has attacked the motor or association centres, or penetrated to the ventricle, then radical extirpation is out of the question, and what seems the very unsurgical alternative of partial removal is all we can offer the patient. This, however, in view of slow growth, may bring considerable relief quite comparable with palliation in other surgical fields.

A strong miner, aged thirty-six years, was referred to me a year ago with a history of severe headaches for two months and vomiting for five weeks. He had had some unsteadiness in walking. He had been paralysed in the right hand for seven weeks. For about a month he had suffered severe mental confusion. On examination we found a high-grade bilateral papillœdema. He had a lower right facial weakness,

marked paresis of the right arm and leg, and great apraxia of the right hand. He was mentally obfuscated, showing great perseveration and nominal aphasia. His cerebro-spinal fluid pressure was 430 millimetres of water.

There are seen in this case a very short history and the rapid development of most grave signs. It all suggests a very rapidly developing tumour, involving the left temporo-parietal region in the premotor area. There was, however, in the patient's history a very hopeful note, for we found that he had for six years been subject to epileptic seizures of varying severity. These had commenced by twitching of the right arm and leg.

Ventriculography confirmed the clinical localization, and we proceeded to operation. We found an astrocytoma presenting beneath the cortex, and we removed a large quantity of it. It was not possible to extirpate this tumour completely, but we left a considerable cavity in the brain and closed the skull after an adequate decompression. The patient made a fairly rapid recovery of intellect, and in a few weeks was able to use his right hand again. I saw him a few weeks ago; he is perfectly well, and is again working full time as a coal miner. He has no headache and there is no bulge of his decompression.

This is a good example of the value of the seemingly unsurgical procedure of partial removal of a tumour. The practice is justified by the slow growth of these tumours, and by the fact that so many of their effects are indirect and due to pressure rather than destruction. It is therefore quite logical to perform partial removals and leave decompressions for gliomata of the type of astrocytoma and oligodendrogliomata.

## MENINGIOMA.

The casual observer of bottled pathological specimens would look with surgical envy at the meningioma—so benign as a rule, so well encapsulated, so superficial. The dead, however, has lost the terrors of the living, for blood has ceased to run in its veins.

The meningioma is most benign, but it viciously fights for its prize by hedging itself round with huge blood vessels distributed far and wide in the overlying scalp, bone and dura. An attack upon it constitutes the marathon battle of surgery, and its happy removal the greatest triumph of the surgeon's endeavour. Characteristically the tumour develops slowly in adults, and the story is a long one. A typical history brings hope to the investigator's heart. Not infrequently, however, the meningiomata deceive the surgeon by presenting a rapid history—a fact which has often led to the diagnosis of a malignant glioma and to a feeling of despair. (Figure II.)

FIGURE II. Showing erosion due to meningioma.

The X-ray investigation of a suspected meningioma may be almost final in the making of the diagnosis, the characteristic findings being calcification, hyperostosis, or erosion of the skull. In other instances findings may be quite negative and finality in diagnosis may be achieved only at operation. For the reason then that a meningioma, though slow growing and benign, will often give a short and rapid

history, and that X-ray examination may not always be helpful, there may be great difficulty in the diagnosis of the condition.

Examples in my experience of a characteristic history and of an atypical one are given in the following case histories.

FIGURE III. Showing hyperostosis.

A farmer, aged fifty-four years, gave a history of weakness of the left hand for eighteen months. The hand had been totally paralysed for one year. For two years he had suffered from attacks of loss of feeling in his left side. At other times he had had paræsthesia of the left hand and foot. For about a year he had been forgetful and emotionally unstable, and for the last few months quite irresponsible. He had recently noted a bony swelling on the right side of his head.

There were several clinically interesting features in his history. For instance, he would tell how he could never know where his left hand was, and would have to look for it, often finding it clutching the tail of his shirt or remaining wherever he had last used it. On examination we could understand this by finding complete loss of sense of position. He had been much troubled by the fact that he would be unable to release anything grasped in the left hand, and would often have to return from work grasping his pick axe. This was explained on examination by finding a most powerful grasp reflex. His loss of memory had been most troublesome, and recently he had spent most of his time on his chicken farm chasing the chickens back through gates he had forgotten to close, and then having got them back, once again forgot to close. On examination we found evidence of gross hemisphere involvement. There were complete homonymous hemianopia, left-sided paralysis and loss of sensation. There was a large bony boss in the left parietal eminence (Figure IV), which X-ray examination confirmed as being hyperostosis.

At operation we tackled the formidable business of cutting the bone flap. The bone was enormously thick and vascular, and by the time it had been cut and reflected the patient had lost enough blood and I decided to do no more at that sitting. He recovered well for forty-eight hours, and then became comatose and died.

At autopsy we were unable to see why he had died. There was a huge parasagittal post-Rolandic meningioma (Figures V and VI).

FIGURE IV. Showing hyperostosis in Case I.

One point I wish to stress is that even with such a tumour, this man had no papillœdema and no headache.

This case is quoted as a typical meningioma. The patient was an adult, there was a long and gradual history, with overlying hyperostosis, clinically and shown by X-ray examination.

Another case of meningioma is not typical, and serves to point the moral of how difficult it may be to make a diagnosis from history alone.

A male, aged thirty-eight years, gave a history of paralysis of the right side of the face two months previously. For two months he had suffered from pain behind

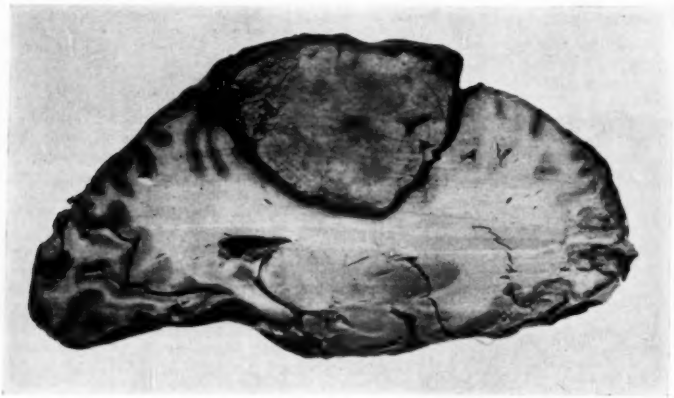

FIGURE V. Showing sagittal section of meningioma.

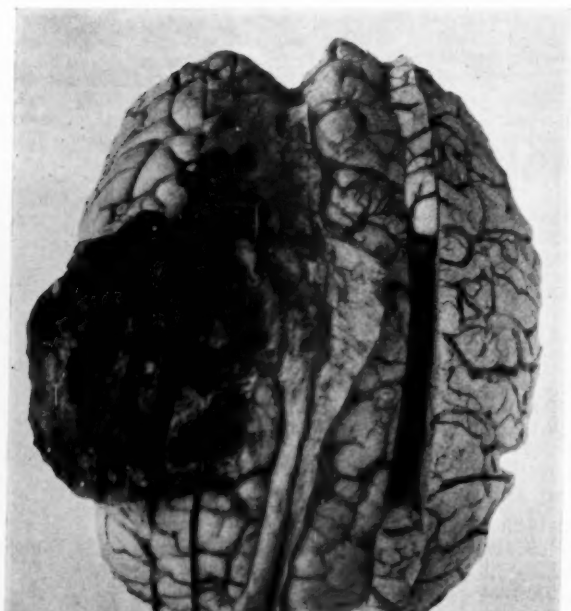

FIGURE VI. Showing meningioma viewed from above.

the right eye, deterioration of vision and drowsiness. On examination we found bilateral papillœdema and slight right lower facial weakness. This was a short severe history, very little in the way of local signs, and I felt that we were dealing with a malignant tumour. X-ray examination, however, shed hope by showing a little calcification in the right frontal lobe.

At operation the brain was under terrific tension, and I had to amputate most of the right frontal lobe. This disclosed a meningioma lying deep to it, and I was able to remove a fair quantity of it before the patient's condition seriously deteriorated, and I had to cease and rely on two blood transfusions to recover him. With the tumour thus partially removed, we stopped. He made an excellent recovery, and there was difficulty in persuading him that there was still trouble present. About six weeks later I operated and completed the removal of a 100 gramme meningioma. He made a quick recovery and very soon was back conducting his grocery business. He is still very well.

Both these cases constituted terrific surgical ordeals, the one proving fatal and the other successful. In the successful case we achieved the most that can be achieved—complete restoration to normal and freedom from the probability of recurrence.

## PITUITARY ADENOMATA.

The pituitary tumours constitute a group of benign tumours which present difficulty on two accounts: firstly, in that they cannot be totally extirpated, there being no adequate pituitary replacement therapy: and, secondly, because they may escape from the confines of the sella in which they remain operable and extend upwards into the hypothalamus and interpeduncular region, in which they are usually inaccessible and ultimately fatal.

From the point of view of diagnosis the pituitary tumour may present a classical picture of bitemporal hemianopia, which, associated with the skiagram showing a ballooned sella, leaves no room for doubt. The picture may be accompanied by acromegalic changes or the less noticeable features of a chromophobe adenoma. On the other hand, the picture may be atypical, the first sign being blindness of one eye or a homonymous hemianopia, either of which may be produced by the adenoma bulging upwards, not onto the chiasm, but either forwards onto the one optic nerve or laterally and backwards onto the optic tract. It is important to remember that the early picture of pituitary tumour is ophthalmic or acromegalic, and often only late, and often too late, do other symptoms such as headache occur. When a pituitary tumour is suspect the visual fields usually hold the clue, but X-ray appearances of pituitary enlargement are very important. It is to be remembered, hôwever, in this regard that enlargement of the sella does not necessarily mean pituitary tumour, but may be secondary to an internal hydrocephalus. Therefore it is not for the radiologist to make the diagnosis, but for the man who sees the whole picture.

Two characteristic cases, one typical and the other atypical, are as follows.

A very typical case is that of a young woman, aged thirty years, who noted that her vision was not as good as it had been. She had difficulty in hitting a tennis ball, but could read quite well. There had been amenorrhœa for some months and fairly severe retroorbital headache. At first time of examination the fields of vision did not betray any abnormality, but X-ray examination revealed a definite ballooning of the *sella turcica*. When she was seen a month later we were able to demonstrate, by the use of the Bjerrum screen with a small object, an early bitemporal hemianopia.

There can be no doubt that this case is an instance of an early chromophobe adenoma. If allowed to develop the condition would progress to

a complete bitemporal hemianopia, with optic atrophy, loss of acuity and eventually blindness.

A very much less typical case is the following:

A man of over sixty years of age had gradually lost the vision of his left eye fifteen years previously. The ophthalmologist had diagnosed primary optic atrophy of unknown cause. Three years after losing the sight of his eye he had suffered a gradual change of personality, a placid and reasonable man becoming the subject of outbursts of ungovernable rage. This change of personality had continued until he had to relinquish all his rather important business affairs. For the past four years he had had attacks of severe headache and vomiting. During the last few weeks he had had epileptic fits following osteopathic manipulation of the neck, and had become comatose. He was not cooperative and was difficult to examine, but it appeared that he was weak on the right side. A diagnosis of left frontal tumour was made; this, however, was not found at operation, which had to be curtailed owing to the patient's poor condition. He died a few days later, and autopsy revealed a very complete story. The tumour was a huge pituitary adenoma. Fifteen years previously it had evidently escaped from the sella to the left optic nerve, which it had destroyed. Then, bulging upwards, it had assaulted the under surface of the frontal lobe, leading to progressive change of personality and attacks of sham rage. It had then gradually grown backwards into the interpeduncular fossa, leading to blockage of the ventricular system, headache, vomiting and eventually coma. (Figure VII.)

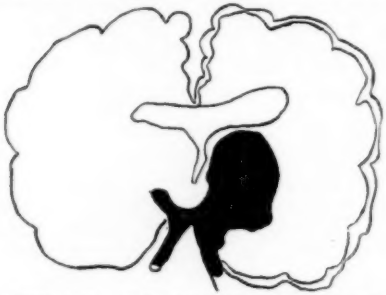

FIGURE VII. Diagram showing adenoma burrowing into the hemisphere.

This is an example of an atypical though thoroughly logical history. If in the first instance the tumour had bulged up in the mid-line and caused chiasmal pressure, the patient would have had bitemporal hemianopia, and the diagnosis might have been made. It is therefore important to remember that the pituitary adenoma may press either on the chiasm, the nerve or the tracts, and in each case the early field defects will tell a different tale.

The pituitary tumour when diagnosed presents no extreme difficulty in attack. The transsphenoidal route has generally been abandoned in favour of a transfrontal, as this allows one to see what is being done. Difficulty arises in deciding how much to do. Usually one must be satisfied to see so much tumour removed that the optic chiasm and nerves are free from pressure. We cannot say what recovery will take place after operation. It may be dramatic, or it may be negligible. We cannot say how long the improvement will be maintained. It may be for years, or may quickly regress.

The first occasion on which I removed a pituitary tumour was about six years ago.

The patient was an elderly man, who had practically lost all vision and was just able to count fingers. I performed a transsphenoidal operation, and he got a rapid and excellent recovery of acuity, being able to read small print within a few days. This improvement has been maintained until the present time.

An interesting contrast is a woman who had a chromophobe adenoma, and who had been treated somewhat successfully with deep X-ray therapy for about a year.

Her vision then underwent rapid deterioration, and when I saw her, perception of light was present in one eye and she could only count fingers with the other. At

operation I evacuated a soft cystic tumour. The good eye made a rapid recovery, so that she was able to read small print. Within about six months, however, it had gone off again, and I again operated and evacuated a soft tumour recurrence. Again she recovered, but in another six months could no longer read. This time I decided to try deep X-ray therapy, which was again successful, and she has now maintained her improvement for about one year.

Often deep X-ray is helpful in the chromophobe tumours and is worthy of conservative and carefully checked trial before operation or in case of a recurrence. Taken by and large, perhaps a pituitary tumour is the most satisfactory of all tumours, for its removal is so likely to restore vision dramatically and to preserve it. Closely linked to the pituitary tumours are the craniopharyngiomata, benign cysts of congenital origin, but malignant in that they can rarely be successfully removed, and in that being situated in the hypothalamic and chiasmal regions, they eventually destroy sight and greatly shorten life.

## ACOUSTIC NERVE TUMOURS.

Acoustic nerve tumours are slow-growing neuro-fibromata, most benign pathologically, and in specimens appear to be encapsulated and easily enucleable. They are situated in the cerebello-pontine angle, and should therefore present a most classical picture. The typical history of an eighth nerve tumour is rather long, commencing with tinnitus and deafness in one ear, going on to unsteadiness in gait, possibly facial neuralgia, and then severe headaches due to internal hydrocephalus.

Typically we find eighth nerve involvement, usually associated with some involvement of the seventh and often of the fifth, cerebellar signs on the same side, pyramidal interference on either side, and evidence of internal hydrocephalus (Figure VIII). Often, however, owing to cross-compression effects, these signs are strangely mingled and mistakes are easily made.

These are most difficult tumours from all points of view. They are difficult to diagnose.

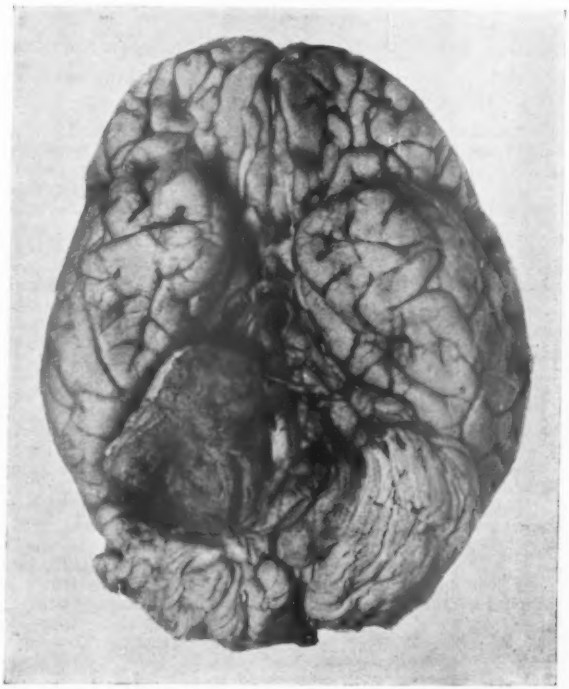

FIGURE VIII. Showing acoustic neurinoma.

I have operated on two patients who were regarded by competent neurologists for some time as suffering from disseminated sclerosis, and I am also guilty of having made the reverse mistake. Where neurological signs are equivocal we can investigate by ventriculography. The typical angle tumour, as the result of compression and dislocation of the brain stem, will have produced an internal hydrocephalus, but in the disseminated sclerosis to which I referred we were deceived because the patient also had very large symmetrically dilated ventricles.

When it comes to surgical attack we are on the horns of a dilemma. Early attempts at sweeping the tumour out whole were all fatal. Cushing then introduced his practice of doing an incomplete or intracapsular removal. This had a very reasonable mortality, but it is inevitably followed by recurrence, which means a very much more difficult operation, and on a third subsequent occasion successful attack is almost impossible.

In order to improve matters, several authorities advocate the scrupulous total removal of the tumour. This is obviously a most difficult procedure, and except in very expert hands will be likely to prove fatal, for we are to remember that these tumours burrow medially and embed themselves actually in the brain stem. Their removal therefore is likely to be embarrassed by most troublesome hæmorrhage from a region which will not tolerate compression or heat, and to be followed by severe reactions of the hyperthermic variety.

## OTHER BENIGN CONDITIONS.

There are rare benign cystic conditions occurring within the skull which may yield entirely satisfactory results.

A well developed girl, eleven years of age, came to me with a history of headache and vomiting for nine months. The attacks were severe and frequent, and had interfered with her schooling. Three weeks before seeing me she had become unsteady in her gait, reeling about, with a tendency to fall to the left. I made a diagnosis of left cerebellar tumour, probably astrocytoma. At operation I removed a large cyst the size of a duck egg, which turned out to be dermoid in origin (Figure IX). She made an excellent recovery, and has been a normal and healthy child ever since.

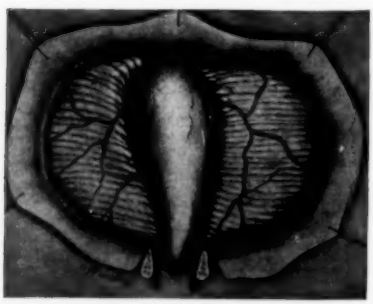

FIGURE IX. Showing dermoid cyst of cerebellum.

Another interesting case was that of a small boy, aged six years, who had been having localized fits in the left leg for about a year. These fits were very frequent, occurring several times a day. Attendance at school had become impossible. He was also a very emotional child, and most difficult to manage. Our X-ray examination revealed some thinning of bone over the parietal eminence. At operation I disclosed a large subcortical cyst. In the walls of the cyst was a tiny hæmangiomatous tumour. I removed this most easily. The child made an excellent recovery, and his personality changed, becoming most tractable and likeable. He had no more fits.

## CONCLUSION.

I have in this review sought not to make an exhaustive list of benign newgrowths or to cram into the time all that can be said of them.

We have seen that the benign newgrowth offers a very satisfactory field for surgery, but is fraught with many difficulties. The characteristic history is gradual onset and slow development, but these points, though in a positive sense of great value, in a negative sense may prove fallacious. On occasions X-ray examination is of the greatest value in clinching the diagnosis, but may be useless, and the surgeon may then be compelled to attack a case with an open mind as to pathology.

The operative removal of benign tumours may be a sample of the greatest battle of surgery. The prognosis may be excellent as in meningiomata, guarded as in pituitary, or in the partial removal of eighth nerve tumours hopeless, in the sense that recovery of function will be imperfect and that recurrence is certain to occur, possibly with great rapidity. The attack on benign tumours then does not make a story of unqualified surgical triumph, but one of prolonged endeavour, achieving many rewards, but as yet leaving open a wide field for improvement in diagnosis, in surgical attack, and so in ultimate prognosis.

# MALIGNANT TUMOURS OF TENDON SHEATHS.[1]

By E. S. J. KING,
*Surgeon to Out-patients, Royal Melbourne Hospital.*

TUMOURS of tendon sheaths are not uncommon, but the malignant variety has been reported on relatively few occasions. This seems to be due in part at least to lack of recognition of the specific nature of these growths.

In their "*Manuel d'histologie pathologique*", Corneil and Ranvier stated that there are no tumours which have received more different denominations than the sarcomata. It might equally well be stated that no other one name has been applied, in a non-specific manner, to so many different tumours.

More careful investigation of many of the tumours described as round or spindle cell sarcoma has shown that such terminology is inadequate or even wrong. Certain growths, for example, the rhabdomyomata of skeletal muscle, have been considered rare, but the increasing frequency of reports of such cases during the last few years shows that the apparent rarity is due to inadequate investigation of certain of the non-specific sarcomata.

The tendon sheath tumours belong to a similar category. Though truly sarcomatous, they are sufficiently characteristic to be segregated from other forms of connective tissue neoplasms. The innocent tumours of tendon sheaths, for the most part, are not characteristic in that they are composed almost entirely of fibrous tissue, fat or cartilage *et cetera*, and thus do not usually show features which would differentiate them from similar growths in related or adjacent tissues. Even though they may actually have arisen from the synovial membrane, they are so differentiated that in the majority the site of origin cannot be proved.

The malignant forms, however, often do show characteristic histological features and thus their relationship to the synovial membrane of the sheaths may be determined. The characters which so differentiate them are the presence of "synovial spaces" and of mucoid material between the cells. It has been suggested[2][3] that these growths deserve the distinguishing nomenclature of synoviomata or even possibly teno-synoviomata, but the writer would agree with the suggestion of Berger[1] that etymologically the term synovialoma (and, for the malignant tumour, synovial-sarcoma) is more accurate.

In this paper seven cases of the malignant type, which have been encountered by the writer during the last few years, are described in some detail in order to emphasize their peculiarities.

## CASE HISTORIES.

CASE I.—F.Z., a male, aged forty-six years, reported for treatment of several swellings of his left forearm.

[1] Accepted for publication on June 20, 1939.

He had sustained an injury to his forearm four and a half years before coming for treatment. He was assisting to move some heavy boxes when unexpectedly he had to support a large proportion of the weight. He experienced severe pain in the lower part of the right forearm. Within a few days there was a swelling above the wrist. He was not quite sure when it first appeared.

Four years later he injured his forearm again, on this occasion by a direct blow. The swelling, which had remained practically stationary, began to enlarge immediately, and in three months' time there was another swelling further up the forearm. He was working in an almost uninhabited area and was unable to obtain treatment. Two months later still a third swelling developed just below the elbow. A month later—that is, six months after the second injury—he presented himself for treatment.

On examination there was a swelling, about 2·5 by 1·5 by 1·0 inches, ovoid in shape and lying in the region of, and apparently attached to, the tendon of the *flexor carpi radialis* muscle. A second tumour, somewhat larger, occupied the middle of the front of the forearm, and a third, somewhat smaller, lay in the common origin of the flexor group of muscles (see Figure I).

In view of their clinical malignancy, the masses were given deep X-ray therapy. This had no appreciable effect on their size. Five weeks later amputation was performed through the arm. The patient was lost sight of, though subsequently it was ascertained that he developed a mass in the left axilla (considered to be enlarged lymph nodes), that an X-ray examination showed shadows in the chest that were diagnosed as secondary tumours, and that when he died of "pneumonia" ten months after operation no post-mortem observations were made.

*Pathological Investigation.*—The tumour near the wrist was a fibrous growth, somewhat irregular in shape and about one and a half to two inches in diameter. On gross section it showed a whorled appearance. It was attached intimately to the sheath of the tendon of the *flexor carpi radialis* muscle. The second growth, ovoid in form and from two to two and a half inches in diameter, was softer and a more uniform grey on section. The third nodule, rounded, firm and white on section, was one inch in diameter. These lay in the intermuscular fascia.

FIGURE I. Drawing of the forearm (Case I) showing the three tumours, the primary growth in the region of the tendon of the *flexor carpi radialis* muscle of four and a half years' duration, the second growth in the substance of the flexor group of muscles of six months' duration, and the third tumour (of three months' duration) in the common flexor group at their origin.

Microscopic examination of the tumours showed them to be spindle cell connective tissue growths. The second and third growths were more cellular than the primary tumour.

The great majority of the cells were of typical spindle form, somewhat larger than normal fibroblasts, and they varied somewhat in size, but no giant or multinucleated cells were observed. A number of spaces lined by cells in the same way as synovial tissue were found scattered throughout the tissue. These were most numerous in the primary growth, but a few were found in the others. In a few areas there were collections of spheroidal cells between which there was a quantity of mucoid material. These were most numerous in the middle growth.

CASE II.—J.F., a male, aged fifty-one years, attended for treatment of a lump on the anterior aspect of the right wrist. Twelve months before seeking attention he had

"sprained" his wrist, shortly after which he noticed a lump in the forearm just above the junction of the forearm and wrist. This had increased slowly in size.

On examination there was a semi-cystic elongate swelling, one and a half inches in length, occupying the region of the tendon of the *flexor carpi radialis* muscle. It was diagnosed as a ganglion and was removed without difficulty. It formed a complete cuff for the tendon and was not adherent either to the tendon or to the surrounding tissues. The wound healed uneventfully.

*Pathological Examination.*—The cuff of tissue measured one and a half inches long and was one-quarter of an inch thick. It was soft and elastic, and on gross section

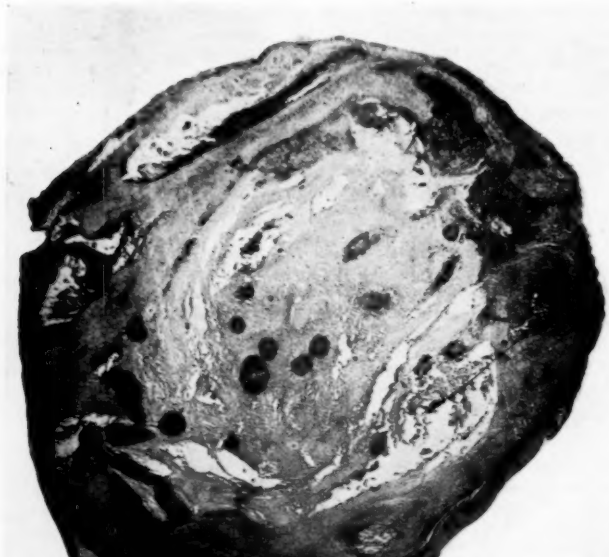

FIGURE II. Low power photomicrograph of a section taken from the tumour on the sheath of the *flexor carpi radialis* muscle (Case II). There are areas of cellular activity and a large amount of mucoid material lying between them. ×10.

was found to be a soft, almost "œdematous", fibrous tissue with some areas of mucoid material.

Microscopically there were cellular areas interspersed with a non-cellular mucoid tissue. The cellular tissue was composed of closely packed cells, in many areas spindle in form, but in others of a spheroidal character. Between the cells of both types, but especially the spheroidal forms, there was a mucoid material staining slightly with muci-carmine. Many spaces of the "synovial" type were to be found, especially amongst the spindle cells (Figure III). Spaces amongst the spheroidal cells were less well defined, but in some areas appeared to be a preliminary stage in the development of the typical spaces. Between the groups of cells the non-cellular tissue was partly mucoid in character, but much of it did not give any staining reactions to suggest that it was mucinous (Figure II).

*Further History.*—Four months later the patient reported, having a diffuse somewhat hard swelling occupying the whole length of the tendon of the *flexor pollicis longus* muscle in the thenar eminence, and the growth had recurred in the region of the original tumour. There was also a small nodule attached to the sheath of the tendon of the *extensor pollicis longus* muscle on the back of the wrist. This last tumour was removed and an attempt was made to remove the tumour occupying the sheath of the *flexor pollicis* muscle. Owing to infiltration of the tissues adjacent to it, this was not possible.

He was sent for deep X-ray therapy. In two months the tumour of the thenar eminence had enlarged and was invading the palm; there was evidence of recurrence in the original wound above the wrist, and there was also a small recurrence in the small wound on the back of the wrist. There were no enlarged glands in the axilla, and amputation through the middle of the forearm was performed. He was then lost sight of and no further history was obtained.

*Pathological Examination.*—Tumour tissue surrounded the tendons of the *flexor carpi radialis* and *flexor pollicis longus* muscles. It could be separated by sharp dissection from the tendons, but was invading the surrounding tissues so that no clear line of demarcation was found. The growth over the *extensor pollicis longus* muscle was also adherent to the tendon and infiltrating the adjacent tissues. All the tumours were white in colour and fibrous in texture.

Microscopically the tissue consisted of irregular, fairly closely packed spindle cells, with a little fibrillar intercellular material. A very few areas showing intercellular mucinous material were found. In several parts of the tumours there were irregular clefts and spaces which were lined by a "synovial" type of tissue (Figure XIV).

FIGURE III. Photomicrograph of portion of a section taken from Case II. Two results of cellular activity are shown: (i) the formation of a "synovial" space due to differentiation of the cells in relationship to a surface, and (ii) the formation of irregular collections of mucinous material between cells. ×120.

CASE III.—A.J., a female, aged fifty-four years, sought treatment for an "infected toe" which she had had for twelve months.

On examination there was enlargement of the middle toe of the left foot. A fungating mass with heaped-up edges and ulcerating base was present on the inferior aspect of the toe. The toe was involved almost to its junction with the foot. This tumour was illustrated in a previous paper.[2] The toe was removed by disarticulation through the metatarso-phalangeal joint. Convalescence was uneventful, and on the patient's discharge from hospital there were no glands palpable in the popliteal or inguinal regions (with the exception of one just below Poupart's ligament, which was slightly smaller than a corresponding one on the right side).

*Microscopic Examination.*—The tumour consisted of a mass of spindle and polyhedral cells, showing a somewhat clear non-granular protoplasm. The nuclei were but slightly larger than those of normal connective tissue cells, and showed but little variation in size. The cells were closely packed together and there was very little intercellular material. They extended from the skin epithelium, or where this had disappeared from the surface, to the subjacent tendon, which was invaded by the tumour.

There were numerous narrow elongate spaces scattered throughout the growth and presenting a characteristic picture (Figure IV). The lining of these spaces was of a characteristic "synovial" form (Figure V).

*Subsequent Course.*—She was not seen again until eighteen months later, when she came into hospital with a large mass of matted lymph nodes in the left inguinal region. She was in a moribund condition and died shortly afterwards.

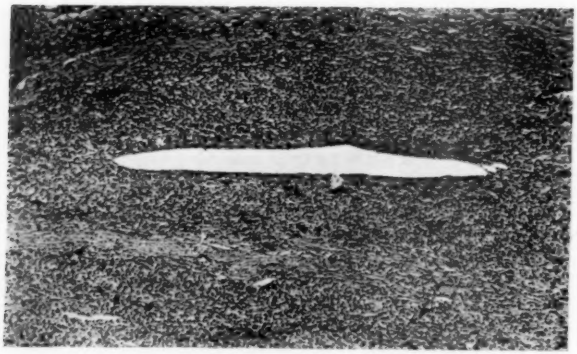

FIGURE IV. Photomicrograph of portion of a section (Case III) showing the appearance presented by a typical "synovial" space. × 42.

*Post-Mortem Examination.*—The scar of the operation for removal of the toe was quite normal. There was no local recurrence. A mass of nodes containing soft white tumour, with areas of pigmentation (shown to be hæmatogenous in type) were found in the left inguinal, iliac and lower aortic regions. There was some extension into the pelvis, and the bladder and left ureter were invaded. There was a left hydronephrosis. No other secondary growths were observed in any other part of the body.

Microscopically the tumour tissue consisted of masses of large pleomorphic cells, which contained a variable amount of finely granular protoplasm and large nuclei (Figure VI). Some of the cells were multinucleated and there were some mitotic figures. The cells were separated from each other by a small amount of clear non-staining material.

CASE IV.—B.R., a male, aged thirty-eight years, sought attention for a swelling on his right ankle of two years' duration. He had noticed a slight swelling on the outer side of the ankle "behind the ankle bone" which developed after a "sprain" two years previously.

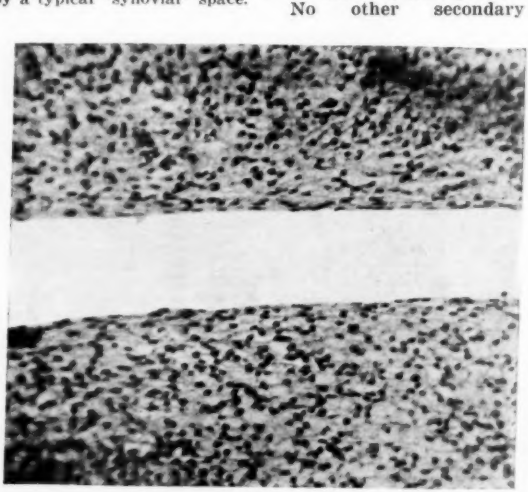

FIGURE V. Higher power view of portion of the tissue shown in Figure IV. × 130.

On examination the swelling was ovoid, attached to the sheaths of the peronei tendons, and about 1·0 by 0·5 by 0·25 inch in dimensions (Figure VII). It was removed easily, appearing to have no definite attachments except to the tendon sheath.

*Microscopic Examination.*—The tissue was composed of a cellular connective tissue of the spindle cell type. There was some mucoid material between the cells, and though this was small in amount in the majority of the material, in some areas it occupied about half of the tissue.

*Subsequent Progress.*—Three months later the patient returned and he now had a swelling, larger than its precursor, beneath the scar. It was infiltrating the surrounding tissues. An extensive removal was performed. Microscopically this tissue was more cellular than the previous material, the cells were more irregular in size, and there was very little intercellular material and none that was mucinous.

Six weeks later the mass had again recurred and amputation through the leg was performed. The tumour tissue resembled that of the preceding tumour.

He then failed to report, but six months later was admitted to hospital and died rapidly of "cardiac failure".

*Post-Mortem Examination.*—He had a mass of enlarged lymph nodes in the right groin. The wound of the amputation had healed satisfactorily, and there was no recurrence in this region. There were four small nodules in the lungs (one-quarter to one-half an inch in diameter), but all the other organs were clear. All these growths showed a very anaplastic, indifferent type of connective tissue, which showed no indication of a synovial origin.

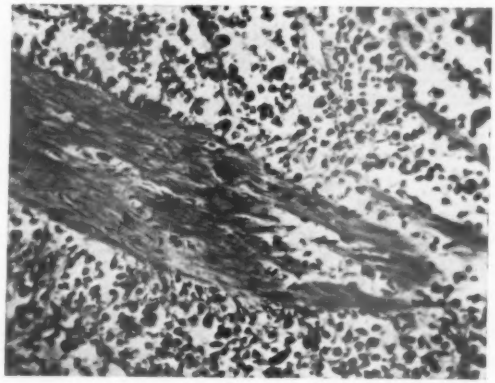

FIGURE VI Photomicrograph of portion of tumour invading the bladder wall (Case III). The tumour tissue does not show any characteristic differentiation. × 100.

CASE V.—M.S., a female, aged fifty-seven years, sought treatment for three swellings on the left forearm.

FIGURE VII. Drawing of the foot (Case IV) showing the elongate tumour occupying the region of the peronei tendons where they pass behind the lateral malleolus.

At this time one mass which was just proximal to the wrist had been present for ten years, a second just proximal to this for two years, and another near the elbow joint for four months.

The first swelling developed immediately after a strain occurring while the patient was wringing out hot clothes. She experienced pain just above the wrist and a swelling was noticed. This remained about the same size, with some slight variation, for eight years, when it began to enlarge. About this time the second lump appeared and grew slowly. Later (the exact time being uncertain) the third swelling developed.

On examination there was a swelling lying deeply between the *flexor carpi ulnaris* and the *palmaris longus* tendons. It was firm, tense, non-fluctuant, about 1·5 by 2·0 inches in diameters and apparently ovoid in shape. The second growth lay just proximal to and almost continuous with this. It was 2·5 by 1·5 inches in diameters, softer than the first tumour and slightly tender on pressure. Just proximal to the elbow joint, lying

between the brachio-radialis and the *pronator teres* muscles, there was a small hard nodule about half an inch in diameter. The axilla was clear. A fourth nodule was found just anterior to the space between the heads of the third and fourth metacarpal bones. It appeared to be attached to the sheath of the tendons of the ring finger.

The last-mentioned tumour was removed and the remainder were given deep X-ray therapy. The proximal and distal growths appeared to diminish in size over a period of six weeks, but the middle one was unaffected.

Removal of the three tumours in the forearm was now performed and radium needles were inserted. The wounds healed satisfactorily. Now, four years later, there is no evidence of recurrence and there are no enlarged glands in the axilla. The chest is apparently clear.

Macroscopically the tumours were ovoid in shape and apparently encapsuled. The second tumour in the forearm was somewhat mucoid on section, but the others were fibrous.

Microscopically they all showed the structure of "fibro-sarcomata"; there was some accumulation of mucoid material between the cells, this being most obvious in the sections taken from the middle growth in the forearm. There were very occasional spaces of the "synovial" type in the tumour near the wrist.

FIGURE VIII. Drawing of the foot (Case VI) showing the swelling attached to the extensor tendons of the foot.

CASE VI.—L.M., a female, aged fifty-two years, complained of a swelling on the front of the right ankle of three years' duration, which had been increasing in size for three months. Originally it had been painless, but recently there had been some pain and tenderness (Figure VIII).

On examination there was an irregular lobulated swelling, soft, non-fluctuant, about 2·0 by 1·5 by 1·5 inches in size and attached to the sheath of the *extensor digitorum longus* muscle. This was removed.

*Microscopic Examination.*—The tissue was composed of spindle and spheroidal cells, the former predominating, lying in a fibrous and mucoid stroma. The amount of intercellular material varied considerably in various parts of the growth; some areas were very cellular, there being but little tissue between closely packed cells; in other parts the cells were separated by a relatively large amount of fibrillar material. Where the cells were predominantly spindle in form the intercellular material was mainly fibrous in character, but in areas where the cells adopted a more spheroidal form the material was mucoid in type. No spaces comparable with those seen in the tumours were found.

*Subsequent Course.*—Three months later there was a recurrence of the tumour at the site of the scar. Examination of the inguinal and iliac regions showed a swelling in the right iliac fossa, although the inguinal nodes were not obviously enlarged. A swelling was found in the right hypochondrium. Laparotomy revealed a tumour involving the left lobe of the liver near the gall-bladder. Unfortunately this was not examined microscopically.

Three months after this the patient died. The tumour of the foot was, by this time, irregularly hemispherical and two and a half inches in diameter. She left hospital a few days before death and post-mortem examination was not obtained.

CASE VII.—E.W., a male, aged thirty-four years, complained of a swelling in front of the right wrist of eight months' duration. He had been advised that it was a ganglion and should be dealt with by subcutaneous rupture. This, however, had not been done. It had been increasing gradually but steadily in size.

On examination there was a semi-cystic swelling three-quarters of an inch long and half an inch wide lying along and closely related to the tendon of the *flexor carpi radialis* muscle just one and a half inches proximal to the transverse carpal ligament. No axillary or epitrochlear nodes could be detected.

Because of its position on the front of the forearm and the steady increase in size, it was diagnosed as a tendon sheath tumour and excision was advised.

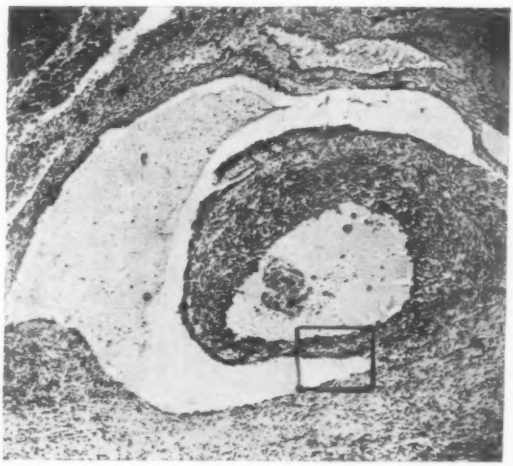

FIGURE IX. Photomicrograph of part of the tissue of the recurrent growth (Case VI) showing the presence of spaces in the tumour. These contain some blood, probably due to trauma at the time of removal. (Rectangle indicates area shown in Figure X.) × 44.

Under (intravenous) "Novocain" anæsthesia of the forearm an incision was made longitudinally and the mass delimited. The tendon of the *flexor carpi radialis* muscle was cut across in two places, proximal and distal to the margins of the tumour, and both tendon and mass were removed together. A radium needle was inserted and the wound was sutured. The needle was removed at the end of a week and the wound healed without undue delay.

Microscopically the mass was shown to consist of masses of polyhedral cells similar in form and distribution to those observed in Case II. There were some "synovial spaces" in parts of the tumour (Figures IX and X).

The patient has been observed at intervals now for four years, especial attention being directed to the epitrochlear and axillary regions, but there has been no evidence of recurrence or metastasis.

## CLINICAL CHARACTERS.

The tumours arise (in the cases described here) during the fourth, fifth and sixth decades. There is no special predilection for either sex.

A history of injury, usually a "strain", followed almost immediately by a "lump", is often given. The sudden onset of pain, with its gradual subsidence, suggests that there has been a tearing of some tissue fibres and hæmorrhage. This

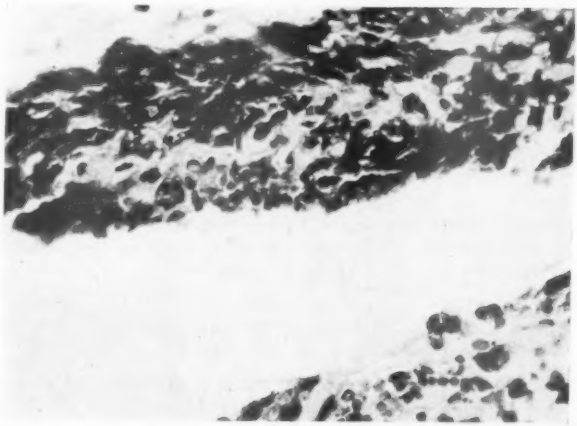

FIGURE X. Higher power view of portion of the tissue shown in Figure IX (at rectangle marked). The lining resembles that of inflamed joints. × 340.

swelling persists, although there may be some variation in size. Then ensues a latent period, sometimes of several years' duration. Very slow growth may occur during this time. A new phase then ensues in which the tumour begins to grow and to invade the neighbouring tissues. This stage is sometimes initiated by another injury, possibly including that of operation. It is more usual, however, for the mass to have begun to enlarge before treatment is sought, in which case the malignant features cannot be attributed to the trauma of operation. In some cases the growth may be obviously malignant from the outset.

Spread of the growth takes place along the sheath of the tendon and may occur from one to a neighbouring sheath, as happened in Case II. Here

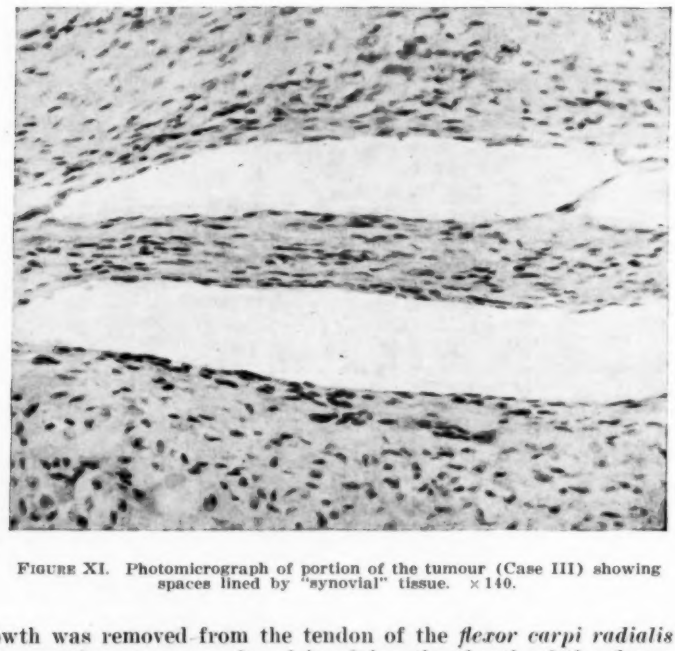

FIGURE XI. Photomicrograph of portion of the tumour (Case III) showing spaces lined by "synovial" tissue. ×140.

the growth was removed from the tendon of the *flexor carpi radialis* muscle and later another mass was found involving the sheath of the *flexor pollicis longus* muscle. The spread from one to the other appeared to take place at the site of crossing of the two tendons.

In other cases the spread is along the muscle planes, for example, in Cases I and V. Invasion of surrounding parts occurs and involvement of the skin sometimes results in ulceration and fungation.

One curious feature, observed in Cases II and V, was the development of a tumour nodule on a tendon on the back of the wrist or lumbrical space at a distance from the primary growth on the front of the forearm. It is difficult to explain this development by any ordinary form of lymphatic or tissue spread.

Metastatic growths occur in the regional lymph nodes and also in the liver and lungs.

The tumours at first are well circumscribed and the primary growth is usually attached to the sheath of a tendon. Pain is usually absent, particularly in the early stages, but the growths are sometimes tender, particularly if they have been traumatized or when they are growing rapidly. There is little interference with movement until the tumour mechanically interferes, by its size, with the action of muscles or a joint.

### MACROSCOPIC APPEARANCES.

The first tumour is usually small, rounded or ovoid and attached to the sheath of a tendon. It may involve the sheath round the whole circumference of the tendon, thus forming a cuff of tissue (Case II). At first it is not adherent to the surrounding structures and may be dissected readily from these.

On section the mass is fibrous, with opaque white patches here and there. It may be hard, elastic or cystic in consistence. The cut surface often shows a definite whorled arrangement. Spaces containing mucoid material may be present or areas of tissue may present a gelatinous consistence. Sometimes they may resemble the more solid forms of ganglion.

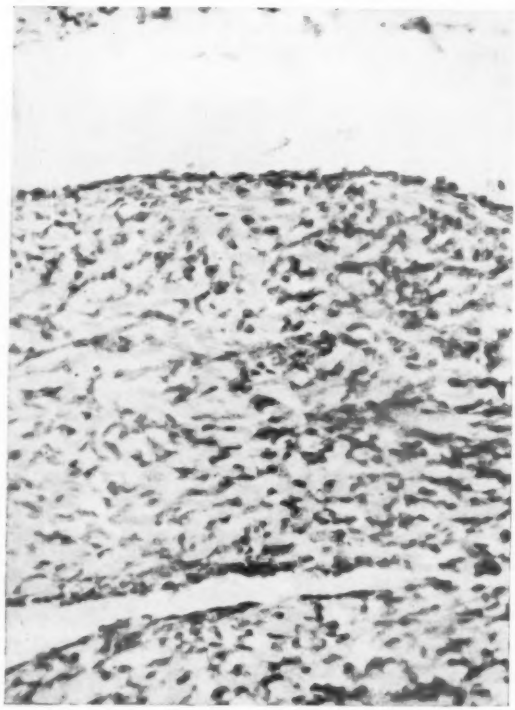

FIGURE XII. Photomicrograph of a portion of the tumour from Case IV. Typical spaces are shown. × 140.

Later the growth becomes adherent to the surrounding fascial planes and muscles by invasion of these structures. Adherence to tendons is usually late, but becomes more obvious as the tumour progresses. In the later stages the growth becomes a solid, white, opaque, fibrous mass, and though apparently demarcated from the surrounding tissues, cannot be separated from them readily.

Secondary growths in fascia, muscles or in lymph glands exhibit a similar white opaque appearance, which, however, does not always show the fibrous character of the primary tumour. There may be considerable discoloration from hæmorrhage.

## MICROSCOPIC APPEARANCES.

The tumours present a variety of appearances, which, however, appear to be due to various combinations of a few fundamental forms.

The cells may be spindle, spheroidal or irregular in shape. The first two constitute very characteristic types. The spindle cells vary somewhat in size, but are arranged in the manner of fibrous connective tissue tumours, so that some of the tumours may be indistinguishable, in many areas, from fibrosarcomata. There may be a large amount of fibrous or fibrillar connective tissue between the cells, but at other times the cells are larger, contain more protoplasm and there is relatively little material between them. Such tissue may merge into an undifferentiated type. Spheroidal cells often present a very

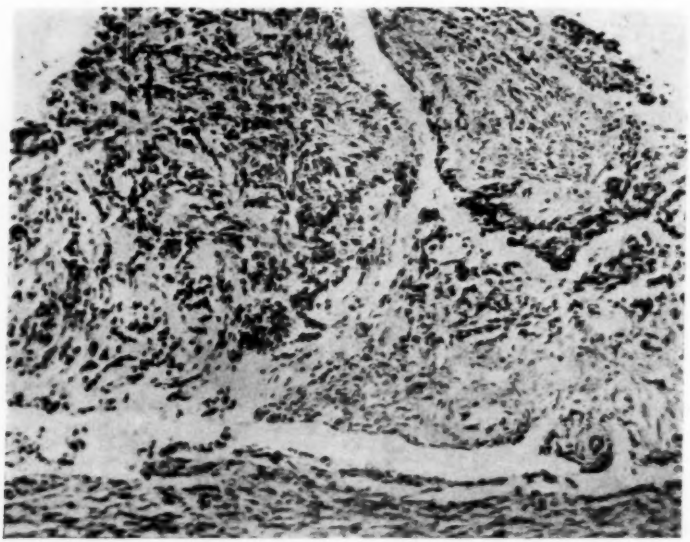

FIGURE XIII. Photomicrograph of a cellular part of the tumour (Case IV) showing irregular but well differentiated spaces. × 180.

characteristic appearance. They are large, with large nuclei and a clear, sometimes vacuolated, protoplasm. They are often closely packed and may suggest, at first sight, an epithelial neoplasm. There may be very little intercellular material, but often there is some mucoid material, and cellular areas merge into zones in which this intercellular mucoid tissue predominates. Indifferent and irregular cells are variants of these two forms and show considerable variation in size, shape, type and amount of protoplasm *et cetera*. Syncytial masses and giant cells may be found and, in some growths, some of the cells may be of the xanthomatous type. These usually occur in groups.

The interstitial tissue occurs in three main forms. Mucoid material occurs most characteristically in relationship to spheroidal cells. The amount varies greatly, from a very small scarcely recognizable quantity to large collections.

between groups of cells, which may resemble the distribution of such material in ganglia. Less commonly this material is associated with spindle cells and occasionally there may be an ordinary mucoid connective tissue. Fibrous connective tissue is usually associated with spindle cells. The amount of this material varies greatly and appearances ranging from those of a soft fibroma to anaplastic fibro-sarcomata are to be found. Reticular fibrils may be demonstrated in the areas just mentioned, but are to be found also in the cellular portions in which there is no intercellular material demonstrable by ordinary methods.

"Synovial" spaces constitute a characteristic component of most of the tumours examined. They were found easily in four and in portion of the fifth

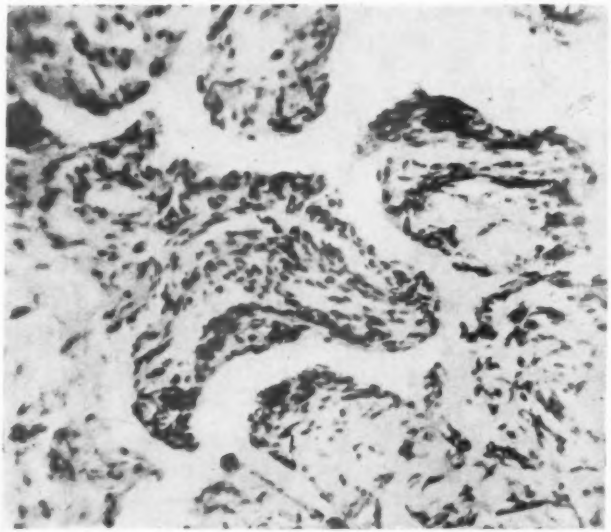

FIGURE XIV. Photomicrograph of portion of the tumour (Case II) showing irregular and complicated spaces, but with a well developed lining. × 160.

of the seven cases. They vary considerably in form, but always show a close morphological similarity to either normal or some abnormal form of synovial membrane.

The most easily recognizable spaces are those in which the lining material is very similar to, and sometimes almost identical with, the normal membrane. This lining is a typical connective tissue containing spindle or irregular cells which are embedded in the tissue, but which in some places appear on the surface. Such tissues differ considerably in the degree of cellularity and sometimes cells may line the surface almost throughout a section and thus give an "endothelial" appearance. Such areas, however, may be found to be continuous with more typical zones in the same space. The spaces may

contain a clear fluid, but often strands of mucinous material with a number of irregular cells may be found. Occasionally blood corpuscles are seen, but the spaces do not resemble blood vessels or spaces which are usually very numerous in these tumours.

Other spaces are much less regular in general form and are lined by irregular spheroidal cells, which are closely packed with but little intercellular material. These cells are continuous with similar ones, which show more intercellular material in the deeper tissue. At times the cells adopt a "columnar" arrangement and even a "pseudo-stratified" formation. When these spaces are

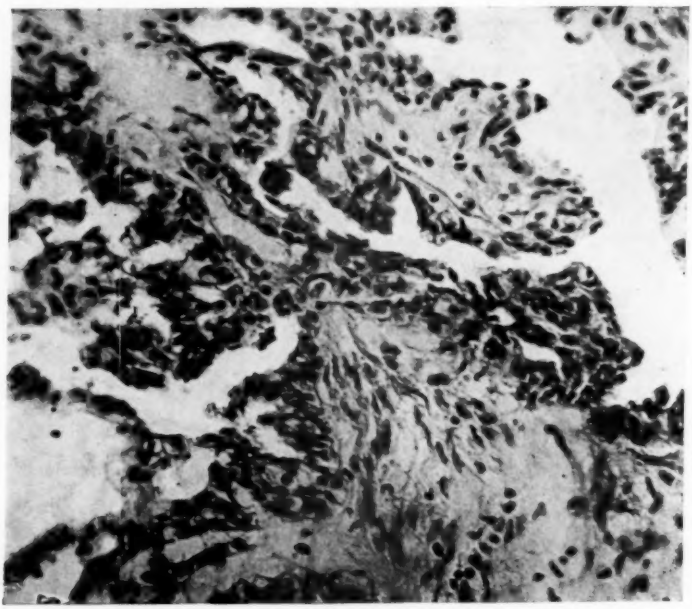

FIGURE XV. Photomicrograph of portion of the tumour (Case I) showing well differentiated spaces with a distinct cellular lining. Though at first sight it might be regarded as "epithelial" or "endothelial", close examination, under higher magnifications showed it to be typically synovial. ×160.

compared with the lining of abnormal joints—for example, in gross osteo-arthritis—the resemblance is very obvious and indeed may be distinguished only after examination of adjacent tissue and by the presence of mitotic figures in the tumour.

The spaces appear to form in two ways. The writer previously described[2] a condensation of the tissue with splitting along the lines of condensation, and further examination of specimens confirms this view. Berger[1] has described a loosening of cells as if their protoplasm had shrunk with a slow evanescence and disappearance. This process appears to be similar to that occurring in ganglia. In an area mucoid material appears between the cells, which thus

become separated, and as this proceeds the cells gradually disappear until the space contains only a fluid which may not show any of the staining characters of mucin. This is the commoner mode of formation of the spaces.

Berger has proposed a classification of malignant tumours, divided them into (i) histiocytic, (ii) endothelial, (iii) mucous, and (iv) indifferent varieties. This is based entirely on the morphological characters of the tissue. It is desirable to consider also ontogenetic and physiological relationships. Our knowledge of the chemical and staining characters of synovial tissue and fluid is still rudimentary, and thus classification must be limited by this.

From a study of the cases described here the writer would propose the following classification:

Synovial sarcoma.

A. Synovial forms:
   (i) Typical synovial type. This contains "synovial" spaces; the cells are usually, but not invariably, spindle in form.
   (ii) Mucoid type. The mucoid material is intercellular in position and varies greatly in amount; the cells are predominantly, but not invariably, spheroidal in form.

   These two types may be found associated in the one tumour.

B. Indifferent forms:
   (i) Fibro-sarcoma, found in recurrent and metastatic growths.
   (ii) Reticular sarcoma occurring, in the present cases, only in parts of the tumours.

The tumours described in this series all fall into one or other of the differentiated synovial forms, but the indifferent forms, where differentiation has proceeded towards ordinary fibrous tissue rather than to synovial structure, are included because, as they were observed in metastatic growths, they will be found in rapidly growing examples.

In his excellent and illuminating paper, Berger refers to a group of these tumours as "endothelial". The writer has not encountered examples which are completely comparable with those illustrated by him, but some sections approximate to them. The linings of the spaces may be almost identical with inflamed synovial membrane, and the writer considers the term "endothelium" as applied to them to be misleading, and has therefore included them in group A (i).

The histiocytic type of Berger is not included since it has not been seen in the absence of some differentiation in the direction of synovial spaces or mucoid tissue. It is probable that such types would occur, but the writer's experience of other examples, which were not personal cases and therefore not included in the above series, has been that when these forms are examined sufficiently completely, evidence of differentiation is found in some or other part of the tumour.

## DIAGNOSIS.

The diagnosis may be made clinically by the discovery of a nodule attached to a tendon or occupying the position of portion of a tendon sheath. Rapid increase in size will suggest that the tumour is malignant, and invasion of surrounding tissues or the development of other tumours leaves no doubt as to the true nature of the mass.

The condition most likely to be confused clinically with a tendon sheath tumour is a ganglion. When the tumour is in a slowly developing phase this may be extremely difficult, but the occurrence of the swelling on a

tendon sheath on the front of the wrist should always suggest that the condition is a tumour. Four of the cases described above occurred in this situation, and two of them were diagnosed at some stage as ganglia.

Striated muscle tumours may be distinguished by their situation in muscle bellies and neurofibromata, by their relationship to nerves as well as by the tenderness and pain along the nerve when the growth is palpated or percussed. Fascial or other connective tissue tumours arising in close juxtaposition to tendons may not be distinguishable.

Microscopically the tendon sheath growths are recognizable when they are sufficiently differentiated, as they were in the cases described, but when differentiation is not present or recognizable, as often happens in metastatic growths, they cannot be diagnosed from fibrosarcomata of fasciæ *et cetera*.

When metastatic growths have developed, their occurrence in the regional lymph nodes would suggest the possibility of the synovial nature of the primary tumour. In such cases investigation of the internal viscera—for example, by X-ray examination of the chest—should be carried out.

## TREATMENT.

Treatment of these tumours is very unsatisfactory.

Local excision, even if extensive, is usually unsuccessful. In six cases recurrences or metastases occurred. Sometimes this is at a distance as well as locally (Case II), thus indicating that local removal, unless made wide of the growth, is insufficient.

Complete removal of the part may prevent local recurrence (Cases III and VII), but lymphatic spread may have already taken place (Case III). In Case III the post-mortem examination showed that the regional lymph nodes and the groups draining these were the only secondary deposits in the body. This indicates that when amputation is performed, dissection of the plane of the regional lymph nodes should be carried out.

Deep X-ray therapy has not, in the writer's experience, been of any value. Radium implantation, combined with excision, has been tried in two cases, and these are the only ones in which a satisfactory result has been obtained.

Treatment therefore should be reasonably wide excision with radium implantation in early cases, and if removal of the lymph nodes is not performed, the region must be observed with particular care. In so far as these growths spread in the early stages by lymphatic vessels or tissue planes rather than by the blood stream—as do the osteogenic sarcomata or the rhabdomyomata—they are more susceptible of successful surgical treatment than are the other malignant tumours.

## SUMMARY.

1. A group of seven malignant tumours of tendon sheaths is described.

2. The clinical features of these tumours are discussed.

3. The microscopic characters of the tumours are reviewed, and the special differentiating features are described and illustrated.

4. The methods of treatment employed in the cases are discussed and their relative value is reviewed.

## ACKNOWLEDGEMENT.

In the cases in which radium was employed in treatment this was given in collaboration with Mr. R. Kaye Scott.

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(2) E. S. J. King: "Concerning the Pathology of Tumours of Tendon Sheaths", *The British Journal of Surgery*, Volume xvii, April, 1921, page 594.

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# COMPOUND FRACTURE OF THE LEG.[1]

By Fay Maclure,
*Melbourne.*

It would be of benefit if the term "compound fracture" was banned from hospital language, for the name focuses attention on a broken leg and distracts it from other and more important issues. The proper mental approach to such a case is, firstly, that a human organism has sustained a serious accident; secondly, that a limb has been severely damaged and a contaminated wound produced, and, thirdly, and of least importance, that a bone has been broken.

## Damage to the Body.

Damage may be manifest in different localized areas of the body and/or may affect the system as a whole.

In military surgery the missile which produces a compound fracture of the leg does not usually inflict other injury; but on occasion it reenters the body and frequently produces an unsuspected lesion more severe than the obvious one, or the missile may be only one of several inflicting wounds of varying severity.

In civilian surgery errors due to incomplete examination of the injured person frequently occur. The majority of compound fractures are the result of motor car accidents, and it is in such cases that the injuries are very frequently multiple. If knocked over, the patient is usually hurled to the ground and struck by projecting portions of the car, and commonly suffers some degree of head injury and of damage to parts of the body; and if he is driver or passenger in a collision he suffers unsuspected spinal, visceral or thoracic injuries. The failure to make a thorough examination at the outset and to assess the damage properly results in irreparable damage to the patient or in disaster.

The injury to the general system is manifest in that condition of lowered vitality which we know as shock.

Such a condition lowers the patient's resistance to infection, it delays or otherwise militates against the success of the necessary surgical operation, and if the time of operation is ill chosen the added trauma may precipitate the shock to a fatal ending. Death by shock a few hours after operation on a compound fracture is often due to surgical intervention on a patient who was not in a fit condition to withstand it. This fact was proven up to the hilt twenty years ago, but there are many to whom it is still unknown today. The correct evaluation of an injured person's vitality marks the practical clinician from an operating surgeon. Whilst our knowledge of its causation and its mode of production is still far from complete, some

[1] Read at Orange, New South Wales, at the annual meeting arranged by the New South Wales State Committee of the Royal Australasian College of Surgeons on October 28, 1939. Accepted for publication on December 5, 1939.

contributory factors are well recognized—cold, pain, tissue necrosis, and blood loss. The appropriate treatment is well known also—experience leads one to rely on transfusion, and if a pint of blood should fail to restore the patient to a satisfactory level, another pint will often elicit the necessary response. It is advisable to see that the rise in blood pressure is maintained for an hour or two before interfering.

## DAMAGE TO THE LIMB.

The upper and lower limbs present two entirely different problems as regards their amputation. In the upper the poorest result, whilst saving the thumb and fingers, is better than the best artificial substitute; but in the lower limb, which subserves the coarser function of weight-bearing and of locomotion, an artificial leg may be superior to a sadly damaged living leg.

In compound fracture of the leg three sites of amputation are commonly used: (*a*) below the knee, (*b*) through the knee joint by disarticulation, and (*c*) through the lower third of the thigh.

The thigh stump necessitates in the artificial limb a mechanical knee joint which is only partially under the patient's control. Disarticulation at the knee joint gives a bulbous stump that offers great difficulties to the limb-maker, and generally calls for reamputation. The below-knee stump should contain at least three inches and at the most the upper half of the tibia; a shorter stump cannot be satisfactorily fitted and a longer stump is undesirable, being often cold, blue and liable to ulceration, whilst offering to the limb-maker no advantage by reason of its greater length. The good below-knee stump enables the patient to be provided with the best substitute for his limb, and in a compound fracture of the leg requiring amputation this should always be the objective.

Amputation may be: (*a*) primary, performed shortly after the injury has been sustained; (*b*) secondary, carried out after an attempt to save the limb has failed on account of sepsis, gangrene, secondary hæmorrhage or other cause.

### *Secondary Amputation.*

When severe secondary hæmorrhage occurs in a septic fracture, even although the blood loss be made up by transfusion, the patient often begins to lose ground against the infection, or the surgical interference necessary to check hæmorrhage determines the death of the limb. In many cases of secondary hæmorrhage, amputation after transfusion is a wise decision. When infection is severe or prolonged, it often becomes apparent that the patient is in danger of losing his life and secondary amputation is necessary in order to prevent a fatal ending.

In a septic fracture, as in any other form of sepsis in a limb, the upper limit of infection cannot be determined: organisms have travelled in the lymphatic channels and intermuscular planes far from the obvious focus. There is no aseptic area in the limb above a septic focus, and amputation must be carried out with this idea in mind. To close such a stump as in primary amputation is to court disaster, and most surgeons can recall having unwittingly committed this surgical sin.

In secondary amputation for sepsis the principle should be the minimum of trauma with the maximum of drainage. The way of greatest safety lies in disarticulation through the knee joint; here no bone is traumatized and

the soft tissues to be severed are smallest in amount and confined to the back of the joint.

*Primary Amputation.*

The decision as to whether or not a limb should be primarily amputated may be an easy one to make; much more often it is exceedingly difficult, but it must be made, and that after a careful review of the damage sustained by the limb and the patient.

In primary amputation the surgeon can frequently select the site and by aseptic operation obtain a healthy below-knee stump, whereas by bad judgement and weak decision he may, when sepsis follows an ill-advised attempt at conservation, be obliged to perform secondary amputation through knee or thigh and leave his patient at considerable disadvantage with regard to an artificial limb.

If any one of the elements of the limb—bony, vascular, nervous, muscular or cutaneous—is so injured as to be beyond repair, the limb must be sacrificed. When these component parts are damaged to a less extent, it is an assessment of the combined damage that will decide the issue. Consideration must be given to the recoverability of each and every one and of the influence of the sum total damage on the functions of the limb.

It is assumed that if the question of primary amputation has to be considered, it is by reason of severe damage, and on that account alone the risk of sepsis is a large one.

*Site.*—If the fracture occurs in the lower third of the leg, even if sepsis should develop, secondary amputation offers a good below-knee stump; conservation therefore will be the choice. If the wound is in the upper third an aseptic primary amputation for a below-knee stump is not assured, and again the decision is in favour of conservative attempt. If this should fail by reason of infection the surgeon may perform secondary disarticulation through the knee joint and still be no worse off. If the middle third is severely damaged, there is room enough to secure an aseptic below-knee stump by primary amputation. If conservative treatment is adopted for a fracture in this area and sepsis should ensue, the chance of securing a below-knee stump is lost; hence the surgeon will incline to primary amputation as the decision of wisdom.

*Time.*—As the hours elapse since the receipt of injury, so mounts the risk of sepsis. An operation undertaken within nine hours of accident offers a reasonable hope of avoiding infection, whilst at twenty-four hours signs of sepsis may be evident; hence time relationship of operation to injury is a factor in the decision.

*Age.*—In youth the tissues possess a greater power of warding off sepsis and of localizing and defeating it should it become established; but in the aged their lack of resistance and inability to withstand prolonged suppuration make amputation the operation of choice.

*Other Factors.*—Impaired general health, degree of shock and rate of recovery from it, and the presence of other injuries are factors which will often help in deciding for amputation. Some patients are by reason of temperament, nervousness, lack of determination, or want of confidence or by associated physical infirmity totally unsuited to use an artificial limb. The economic factor is of importance: in a septic fracture the period of

invalidity may extend to two years or more; in an aseptic amputation the patient may be capable of wage earning within six months.

## TREATMENT OF FRACTURE.

The treatment of compound fracture concerns first and foremost the problem of the prevention of sepsis. When infection occurs the results are frequently disastrous. The patient may lose his life or his limb; at best, there follow osteitis, frequently non-union, further delay before surgical repair can be attempted—in all there is a period of invalidity which may extend well over two years.

It is obvious that above all else no step should be taken nor anything left undone which will add one risk to those already present.

The organisms which may contaminate a compound fracture are of various kinds and of different degrees of virulence; they can be determined by culture of a decoction of an assortment of socks and trousers. Some are simple and non-pathogenic; others are deadly aerobes and anaerobes. A surgeon cannot estimate the degree or the quality of the contamination. His course, his responsibility, is clear-cut—to look upon every compound fracture as being the possible site of gas gangrene or streptococcal infection and to base his treatment on this supposition. To do otherwise is to guess and gamble on the result, and there is no place in surgery for the gambler.

The wound in the leg is made from without or from within. In the former a missile or other violence penetrates or crushes the tissues and breaks the bone; in the other the fractured ends are forced through the tissues to the exterior; in either case the damage to skin and soft tissues may be of the puncture type or these may be extensively lacerated. Some authors note the distinction in the mode of injury and advise methods of treatment for each which are contrary in principle.

The simple fact is that whether the wound is caused from without in or in the reverse way, bone and soft tissues have been contaminated by clothing and skin organisms, and the treatment as regards prevention of sepsis should be fundamentally the same.

In this problem of prophlylaxis, as in every other problem in surgery, reliance must be placed on sound surgical principles.

These are the guiding lights that mark the tortuous channel of safety; one may on occasion become adventurous and by reason of good fortune cross the shallows of danger and still reach port, but the navigator who has learnt to rely on the beacons will in the end have no regrets.

The indications for treatment are: (i) to raise and maintain the general resistance; (ii) to free the wound of contamination and of damaged tissue by excision and *débridement*; (iii) to give exit to traumatic and inflammatory exudate; (iv) to afford the maximum degree of rest to the injured limb.

### *General Resistance.*

The first and most important step in this regard is to counteract the shock and lowered vitality of the patient; this aspect has been discussed at an earlier stage. The next, to raise the resistance against specific bacterial toxins.

*Tetanus.*—The value of antitetanic serum as a preventive measure has been proved beyond all doubt, and has become a routine treatment. This

serves to emphasize the point already made, that a surgeon cannot guess correctly which wound may or may not be contaminated by a particular organism, and therefore all wounds should be treated from this viewpoint. Research work has been carried out which shows that an active immunity may be developed by the injection of toxoids of tetanus and therefore greater protection afforded than by the use of antitetanic serum.

*Gas Gangrene.*—Experimental work done on animals proves that gas gangrene antiserum has a definite value both as a prophylactic and as a curative agent. It is difficult to obtain conclusive proof of its value in dealing with the disease in mankind, but the opinion formed by competent observers confirms its use. Research workers in veterinary science have obtained excellent results in developing immunity against many diseases of animals akin to gas gangrene and produced by intestinal anaerobic organisms. Following this advance in preventive medicine, active immunity has been conferred on man by the injection of toxoids of *Bacillus welchii.* It is probable therefore that in military operations of the future soldiers will be protected against one of the most fatal complications of compound fracture and of gunshot wounds in general.

*Chemotherapy.*—Streptococcal infection, by reason of its rapid extension, its virulence, and its fatal results, is a complication greatly to be feared. The development of the sulphanilamide group of drugs has brought a powerful agent to the surgeon's aid, and whilst it is difficult to obtain evidence of its value as a preventive, it is reasonable to assume that for four or five days following the accident the administration of these drugs should help in prophylaxis.

### *Excision and Débridement.*

The healthy tissues of the body possess in high degree the power to resist invasion by harmful organisms. In accidental wounds the surgeon can assist by well designed operation, but he well knows that he must rely ultimately on the antibacterial properties of living tissue. Devitalized tissues, blood clot and bruised bone can offer little or no resistance to the contaminating organisms; indeed, they form an excellent culture medium for bacteria, supplying food, warmth and moisture. Hence a thorough and complete removal of all such material is a basic principle in the fight against sepsis.

The history of the operative treatment of wounds during the last war is that of a gradual improvement in technique, from the early days of rough cleansing of wounds, through stages where the wound was opened by incision and more carefully explored and mechanically cleansed, to that when cutting away of damaged tissues was practised more and more, until the period when it became definitely established that the more completely and thoroughly the early excision was done, the better were the results.

The ideal method of preventing sepsis in a recent wound is by means of aseptic operation to excise *en bloc* the whole of the damaged skin, fat and muscle, containing the contaminating clothing and débris, keeping the knife in healthy tissue throughout. Unfortunately this ideal cannot be realized in the case of a compound fracture; the presence of nerves, vessels and bone precludes their sacrifice by excision and compromise is therefore necessary.

It is still more unfortunate that many operators fail to appreciate the distinction between the ideal and the compromise; that even in the most

careful excision as applied to fracture there still remains a contaminated wound, one capable of being transformed into an area of sepsis.

The surgical literature dealing with this subject still often leaves its readers with the impression that the technique of excision and *débridement* is capable of rendering the wound sterile; that is far from the truth, and the impression has led many into surgical indiscretions.

*Drainage.*

Another essential in the prevention of sepsis is absence of tension about the tissues of the wound. A leg may be regarded as a cylindrical mass of muscle and other structures encased in an inelastic fibrous sheath; as tension rises above normal within the aponeurosis the blood supply becomes impaired, and this condition of anæmia lowers antibacterial resistance. How great that tension may be is sometimes seen in simple fractures when the cylinder of muscle becomes tight and board-like, the lymphatic flow obstructed to such an extent as to cause blebs in the skin and the vascular supply so damaged that gangrene develops. In sepsis a similar state may be observed when following a prick in the finger streptococcal infection occurs and the finger dies within a few hours as the result of the combination of inflammatory exudate and toxæmia.

Tension in tissues, by rendering them anæmic, becomes the ally of sepsis and the enemy of healing in a contaminated wound. It must be combated by offering to the tissues a free exit to all the blood and traumatic exudate which may be present.

Closure of the wound in compound fractures has many advocates today, but it is exceedingly difficult to find any scientific or surgical reason on which to base its adoption. What are the benefits conferred on the patient by closure and what are the risks? Why is it done?

Is it to convert an open to a closed fracture? Then secondary suture when the danger period has passed achieves the same purpose.

Is it fear of infection from without? Then the provision of an effective barrier by an antiseptic dressing—for example, Lister's double cyanide gauze wrung out of carbolic acid solution—meets the case.

Is it that a closed fracture is easier to deal with than an open one? Not to the surgeon who is master of his craft; to have to rely on plaster technique is a confession of weakness.

Is it to make transport less difficult? The answer is that no patient with a fracture should be transported until the danger of sepsis is over; the principle of rest as a preventive of sepsis is paramount. Should transport be absolutely unavoidable, there is no greater difficulty with an open than with a closed fracture.

Should infection occur every suture is cut—surely an admission that drainage is necessary.

And what are the standards by which the decision for or against closure is made? Are there any well-defined guides or tests to determine the issue, or is it all guesswork? Can any surgeon say that this or that wound is not contaminated by deadly organisms, or can he be satisfied that at the end of any excision and cleansing of a compound fracture he has rid the wound of possible sepsis?

One occasionally hears an operator, faced with doubts as to the wisdom of his procedure, say: "I will take the risk and close this fracture." Let him be reminded that he takes no risk—he forces that on a patient ignorant of the pros and cons, but who would prefer not to be made the subject of what appears to be a gamble as judged by the standard of sound surgical principles.

Increase of tension is possible only when the wound surfaces become reattached. If the glueing together of torn tissues is prevented, then fluids can escape to the exterior. The wound in compound fracture is of a complex nature; as the muscles at the moment of rupture are at different degrees of contraction, so when these have come to rest the track of the tearing is not direct and straight, but at varying levels and tortuous. The broken bone, in being forced through muscles, has shredded them extensively and split them, so that there are multiple intermuscular crevices extending into the main wound.

As a drainage material, rubber tubing fails because it adds not inconsiderable dimensions, is straight and semirigid and does not conform to the undulating track, and the area which it drains is exceedingly limited and does not comprise the many tributaries of the main wound. Rubber dam is thinner, more pliable and, used flat, is capable of draining a muscle plane, but one plane only. The ideal drainage material is "Vaseline" smeared onto the surfaces of the main wound, and, reaching out almost to the limit of the crevices, it delays the glueing and sealing of opposing surfaces and allows exit to traumatic exudate from all parts of the damaged area. Used in conjunction with a mild and slow acting antiseptic in the form of "B.I.P.P.", "Vaseline" forms a valuable aid in the battle against sepsis.

### *Rest.*

Rest, the greatest degree of rest that can be obtained, is another basic principle in the treatment of compound fracture and possibly the most important of them all.

Bone develops in response to the stimulus of function; its function is to act as a prop or stay—to provide the rigid lever whereby the energy of muscle is converted into power and movement; bone has to withstand the stress and strain of muscular contraction.

When a limb is paralysed during the growth period as in poliomyelitis, and the stimulus of function disappears, bone ceases to grow in length and breadth. In a limb suffering from disuse the bone becomes rarefied and the lime salts are absorbed because the stimulus of function has vanished; no longer are strength and rigidity required since there is muscular inactivity, so the bone atrophies. When once again the muscles are brought into action, bone quickens to life, recalcification takes place, strength and rigidity return.

In the case of the simple fracture or of the compound fracture which has escaped infection, the active contraction of muscle elicits a response in the growth of bone, it stimulates ossification and hastens union. Active movements to the limit of pain, provided that deformity is not allowed to recur, are of benefit in improving the circulation, removing traumatic exudate, maintaining muscle tone, preventing adhesions and making for early and solid union.

In compound fracture when danger of sepsis exists or infection is already established, the reverse holds good. The objective then is physiological rest to the injured part, and absence of movement and of irritation of muscle is to be maintained until the tissues have recovered their resistance and healing has advanced sufficiently to defeat the invading organisms and until the field has become aseptic.

Absolute immobilization of the joint surfaces is one of the most powerful means of dealing with suppurative arthritis. It is of equal importance in preventing sepsis in the treatment of penetrating wounds of joints; again it is the most important factor in the control of suppuration in compound fractures when sepsis has developed, and in the prevention of infection in a recent compound fracture there is no single measure more effective than complete fixation of the fragments and the surrounding tissues.

Normal muscle tissue is in a state of tone in readiness to contract in a flash when it is stimulated. Injured muscle or muscle in the neighbourhood of an injury, as in fracture or joint damage, and particularly when this is inflamed, is in a state of hypertonus; it will contract and go into spasm even more quickly and more strongly than in its normal condition. This hair-trigger reflex of muscle at the slightest stimulus of pain or movement of joint or of one fragment of bone on another, will come into action and hammer the fragments or joint surfaces together. This is the mechanism of the so-called "night starts" of destructive arthritis.

It is the repeated small movements of fragments which keep the traumatized area of compound fracture in a state of irritation and so contribute to the development of sepsis. This action has to be antagonized by holding the fragments apart and immovable by a distracting force, a constant and invariable extension of the limb preventing the contraction of muscles which pass over the site of fracture. If the distracting force is intermittent, inconstant and variable, then alterations in the tension of irritable muscle will occur and set up reflex contraction and movement as a result.

There are three essentials in the achievement of complete immobilization by splintage:

1. The limb must be supported in its whole extent; every muscle which crosses the injured part should be controlled from beyond its origin to beyond its insertion.

2. It must be suspended from an overhead frame counterbalanced by weight and pulley to offset the action of gravity.

3. It must be subjected to a constant distracting force in order to counteract the spasmodic contraction of muscle which arises as the result of injury.

Many acts which the patient performs during the day—for example, changing position, shifting the buttocks, getting onto a bed pan, turning the body—are dependent on the use of muscles which pass from the trunk and pelvic girdle to the thigh and leg. The contraction of these muscles is effective only if there is a resistance, fulcrum or purchase point against which they can act.

Such a *point d'appui* is provided when the splint controlling the leg is affixed to the mattress; it vanishes when the apparatus is slung and counterpoised: muscles find their contractions ineffective, so they cease their efforts

and rest is the result. Hence the use of any fixation splint which rests on the bed is conducive to movement in a compound fracture and is contra-indicated.

For similar reasons the custom of pulling the splint by extending weights is wrong in principle; the splint should be free to swing.

Again, if this is the means of applying a distracting force, then it is incorrect, for the body weight acts as the counterextension, and at every move of the patient to and fro in bed, and because of the inertia of the extending weight and the resistance of the pulleys, the state of tension at the site of fracture becomes inconstant and therefore inconsistent with rest.

Most of the requirements for the treatment of compound fracture are supplied by the Thomas splint or some modification of it. No splint in itself, however, is capable of bringing about the desired results. It requires the guiding brain and hand of the surgeon with an understanding of the mechanics of the limb and of the objectives in treatment. Given this, it matters little what the splint is composed of or how it is applied; the splint is only one factor in the treatment, and should be regarded solely as a means to an end—the maintenance of complete immobilization of the fragments and muscles of the injured limb.

# SOME OBSERVATIONS ON THE TREATMENT OF THE BLEEDING PEPTIC ULCER.[1]

By IAN J. WOOD,

*Clinical Assistant to Out-Patients, Royal Melbourne Hospital; Out-Patient Physician, Children's Hospital, Melbourne; Marion Carty Research Fellow, Walter and Eliza Hall Institute of Medical Research.*

THE purpose of this paper is to discuss those patients who are suffering primarily from a bleeding peptic ulcer. Bleeding which first occurs during the course of another illness will not be considered.

During the past five years important changes have been introduced at the Royal Melbourne Hospital in the investigation and treatment of bleeding peptic ulcer. Accurate estimations of hæmoglobin have been made in all these cases. Since 1936 an increased number of massive blood transfusions have been given, and since 1938 treatment has been improved by the introduction of the Meulengracht diet.

Despite these improvements the figures for the three years 1936 to 1938 which have followed the introduction of massive blood transfusion, have shown an increased mortality. Dobson[1] found that among 115 patients treated between 1933 and 1935 there was a mortality of 18%, whereas in the following three years there was a mortality of 27% among 111 patients.

It is certain that these figures do not reflect the effect of the proper application of these methods to the treatment of hæmorrhaging peptic ulcer. In the first place the patients in the public hospital class tend to be left far too long before restorative measures are carried out, and the infinite care and attention which treatment by massive blood transfusions demands, are difficult to apply uniformly over a large series of patients in a public hospital. In any case the number of cases is not sufficiently large for the difference in mortality to be significant.

In my own small series in private practice, twenty-one patients have been treated by the rigid application of the methods here described, with two deaths.

At the Royal Melbourne Hospital resort has seldom been had to surgical intervention for the arrest of gastric or duodenal hæmorrhage. Of 354 patients treated at the hospital between 1929 and 1938, only 29 were operated upon. This small group had a mortality of 66%, as against the mortality of the whole group of 19%. In no case was surgery undertaken early in the illness. Mr. Syme has studied the results of surgery, and he will place his conclusions before you.[2]

It appears that if surgery is resorted to for those patients who are failing to respond to medical treatment and massive blood transfusion, a high post-operative mortality must be expected.

[1] Read at the twelfth annual meeting of the Royal Australasian College of Surgeons, March, 1939. Accepted for publication on June 9, 1939.

When a patient suffering from severe bleeding from a peptic ulcer is first seen, certain observations should be made. In particular, one should obtain a detailed history of the preceding dyspepsia and, if possible, ascertain the amount of blood which has been lost by way of the fæces and vomitus. The most informative of these observations are the appearance of the patient, the percentage of hæmoglobin in the blood, the pulse rate and the blood pressure.

Although its value has recently been criticized by Bennett and Wright[3] (*vide infra*), the hæmoglobin level appears to be more informative than either the pulse rate or blood pressure. However, all three observations are essential. Figure I demonstrates the usual changes which are produced by steady blood loss. While the bleeding occurs there is a progressive fall in the hæmoglobin level. At first the vasomotor system and the reserve stores of fluid fully compensate for the shed blood, and so the pulse and blood pressure remain within normal limits. This phase is followed by one of commencing failure of the compensating mechanisms, the pulse rate rising and the blood pressure falling. Finally, the whole machinery breaks down and severe circulatory failure ensues. The patient sweats excessively and then becomes pale, cold and semicomatose. Death may occur. There is great variation in the susceptibility of different individuals to this peripheral failure. I have, for example, seen a donor for a blood transfusion become pulseless, slightly cyanosed and deeply unconscious after the loss of one pint of blood Figure I also shows the dramatic effects of massive blood transfusion on the hæmoglobin level, pulse rate and blood pressure (Figure I and Figure II are records from the same patient, A.B., described below).

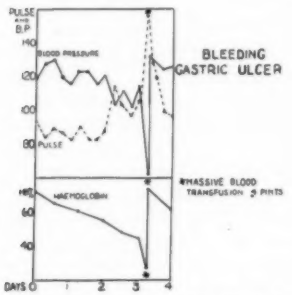


FIGURE I. Showing the effect of hæmorrhage on the percentage hæmoglobin, blood pressure and pulse rate. It will be noted that in the early stages the blood pressure and pulse rate show little change, whereas the level of hæmoglobin slowly falls. With a further drop in the hæmoglobin, the blood pressure begins to fall and the pulse rate rises. This culminates in severe circulatory failure. The dramatic effect of massive blood transfusion is shown (see case report).

The treatment of a patient suffering from a bleeding peptic ulcer consists of rest, alkalinization, and the administration of sedatives, iron and a suitable diet. In some cases a blood transfusion and perhaps surgery may be necessary. Absolute rest should be procured for the patient. He must be urged to spend his time sleeping. He will be aided in this by a liberal supply of fluid by mouth and by small doses of morphine. The more recent methods of investigation and treatment are liable to subject the patient to a constant stream of disturbing procedures. It is the duty of the physician and nurse to guard against this. Above all, the physician should quietly but confidently convince the patient that he will make a complete recovery.

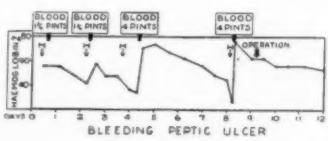


FIGURE II. Showing the effect of repeated hæmorrhages from a chronic gastric ulcer (H) on the level of the hæmoglobin. The hæmoglobin was restored by repeated blood transfusions. Operation was finally undertaken and the bleeding vessel ligated. The patient made an uninterrupted recovery (see case report).

In 1935 Meulengracht[4] advocated the use of a semisolid, high caloric, high vitamin diet, and this appears to be a useful measure. Patients will usually take it readily if they have passed the stage of circulatory collapse. Occasionally they are nauseated and will take nothing but fluids, water being their most frequent desire. Water, abundant carbohydrates, moderate protein, some salt and plenty of vitamins, especially vitamins *B* and *C*, are indicated. To supply these, milk, eggs, vegetable purée, stewed fruit, orange juice and "Marmite" can be given.

Many patients have been suffering from a slow oozing of blood for many months prior to their massive hæmorrhage. This produces a state of iron deficiency anæmia with a low colour index. Blood regeneration is distorted and in abeyance; it is slow to respond to the urgent call which is made after the acute blood loss. Small doses of iron can be commenced immediately, and slowly increased as the patient improves. Ferrous sulphate, 15 grains a day, in divided doses, gives very good results.

Clinical observations cannot fail to convince the most sceptical observer that the introduction of massive blood transfusion by Marriott and Kekwick[5] in 1935 has saved the lives of many patients suffering from bleeding peptic ulcer. There appears to be no valid objection to its use so long as meticulous care is taken to avoid reactions. The improvement in the appearance and well-being of the patient is dramatic. The cry that it causes a dangerous rise in blood pressure is now seldom heard. Slow massive transfusion merely tends gradually to restore the blood pressure to normal levels after it has fallen as a result of circulatory failure. It does not cause a sudden rise of blood pressure to abnormal heights, nor is there convincing evidence that it promotes further blood loss. It is probable that the slow transfusion of blood lessens the tendency to further bleeding by improving the nutrition of the ulcerated area in the stomach or duodenum.[6]

Moreover, massive blood transfusion has greatly lowered the morbidity after hæmorrhage. The success or failure of a method should not be judged solely by whether the patient lives or dies. The morbidity after a critical hæmorrhage may be severe—cerebral degeneration, cardiac weakness and renal failure are to be seen. These may last for weeks or months, or the effects may even be life-long.

Massive transfusion relieves the damaging state of acute anoxæmia to which the cells of the whole body are suddenly subjected.[7]

## INDICATIONS FOR TRANSFUSION.

The indications for blood transfusion may be summarized as follows.

1. Give a transfusion if the hæmoglobin level falls below 40%. It is imperative to have some reserve, for a further hæmorrhage may occur. Thus the hæmoglobin should be maintained above 40%. Should the hæmoglobin fall below this level, a slow transfusion should be given to restore it to at least 60%. Roughly, one pint of blood elevates the hæmoglobin by 10% in an adult weighing ten stone.

2. Give a transfusion if the patient is collapsed, if the blood pressure is below 90 millimetres of mercury, or if the pulse is above 120 per minute even if the hæmoglobin is above 40%. These findings are more significant if they have persisted for several hours. They suggest that hæmorrhage has occurred recently, and that the body is not compensating for the blood loss

by vasoconstriction and restoration of the blood volume at the expense of the tissue fluids. As Bennett and Wright[3] have pointed out, the percentage of hæmoglobin remains relatively high till the blood volume is fully restored. If the hæmoglobin is above 60%, then one pint of blood will usually restore the circulation, unless bleeding is still taking place.

3. Give a transfusion if surgery is decided upon in order to ligate the bleeding vessel. The hæmoglobin should be elevated to at least 60% (preferably above 70%) prior to the operation. While the operation is in progress one or two pints of blood should be run in very slowly for the first part of the operation, and perhaps more rapidly towards the close of the operation when the bleeding point has been secured. In this way a patient can be maintained in excellent condition both during and immediately after operation.

## SURGERY.

The transfusion of blood to restore the hæmoglobin to a level of 60% is, for convenience, termed a "restoration". Surgical intervention to arrest the hæmorrhage should not be resorted to unless at least one restoration has failed to maintain a satisfactory hæmoglobin level. On the other hand, operation should be undertaken before a fifth restoration becomes necessary. Figure II shows the successful outcome of a severe hæmorrhage from a chronic gastric ulcer in a patient who was operated upon after the fourth restoration. It would have been wise to have operated after the third restoration.

A.B., a male, aged forty-five years, was admitted to hospital on April 9, 1938, suffering from hæmatemesis and melena. For the previous three years he had suffered from the typical dyspepsia of a chronic gastric ulcer. During the past month the pain had been worse and was situated high up in the mid-epigastrium. It came on soon after meals, and was relieved by alkalis. On the day of his admission to hospital he had vomited two or three pints of blood. He was pale, sweating, collapsed, his pulse was of poor volume and his hæmoglobin value was 54%. He was given a blood transfusion of 25 ounces with great improvement. On April 10, 1938, the improvement was maintained.

On April 11, 1938, a second hæmatemesis occurred with severe collapse. He was given one and a half pints of 10% glucose in Ringer's solution and 25 ounces of blood. He looked better, but was still pale at the end of this treatment. On April 12, 1938, he was moderately well but pale. On April 13, 1938, he became pulseless, pale and collapsed. He was given a massive blood transfusion of four pints which elevated the hæmoglobin from 35% to 70%. At the end of this he was a good colour and felt much relieved. Operation was considered, but it was decided that this should be delayed.

On April 15, 1938, he was very well. On April 16 he felt well, but his hæmoglobin slowly fell.

On April 17, 1938, severe collapse occurred. He became comatose, pulseless, had stertorous respiration and deathly pallor. He sweated copiously. Four pints of blood were administered by continuous drip (Figure I). He made a dramatic improvement. Operation was decided upon. On April 18, 1938, a laparotomy was performed under ether anæsthetic. The stomach was opened after an ulcer had been palpated on its posterior wall near the lesser curvature and at the junction of upper and middle third. This was oversewn by mattress sutures inserted from within. The patient made an uneventful recovery, no further hæmorrhage being evident. When seen one year later he was perfectly well and had suffered from no indigestion.

Early operation (after the second rather than the fourth restoration) is indicated if a recent X-ray or gastroscopic examination has revealed a definite chronic peptic ulcer, if the hæmorrhages are massive and frequent, or if the patient is failing to withstand the repeated attacks of anoxæmia, depleted

blood volume and circulatory failure. Means[8] considers that older people need operation more frequently, as their blood vessels are involved by atheromatous degeneration and do not clot readily.

By aid of massive transfusion a patient can be operated upon without fear of death from surgical shock, even if an extensive operation has to be performed. The major problems which confront the surgeon are, firstly, the difficulty of locating the ulcer; secondly, the relative merits of a local resection of the ulcer and a radical gastrectomy; and, finally, the justification for a blind partial gastrectomy in the event of an ulcer not being found. Wright-Smith[9] has shown that the common sites from which fatal hæmorrhages occur would be included in a blind partial gastrectomy.

Finsterer[10] and Gordon-Taylor[11] have stressed the fact that with repeated hæmorrhages the nutrition and integrity of the stomach wall are greatly impaired, and its power to heal is diminished. This greatly increases the risk of post-operative complications, such as hæmorrhage, perforation or gastric dilatation.

The Meulengracht diet maintains the patient in a better state of nutrition; the wise use of adequate transfusion lessens the havoc of prolonged anoxæmia. It remains for the surgeon, having used these measures to the full, to make a timely decision to operate. In making this decision he must be fully aware of the good results which are now to be expected from medical treatment and the many hazards that beset surgical intervention.

## ACKNOWLEDGEMENTS.

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# A CONSIDERATION OF CERTAIN DIMENSIONAL FACTORS INVOLVED IN THE INTERNAL FIXATION OF THE FEMORAL NECK.[1]

By D. J. GLISSAN,
*Sydney.*

AT the outset I wish to make clear my belief that two rustless steel nails of the ordinary type, if correctly placed within a fractured femoral neck, will retain the fragments in position as satisfactorily as any other medium, and will cause less damage to the bone than nails of the flanged type.

At the present time a technique is being developed to permit of the placement of two nails based on an accurate estimation of the factors to be discussed below and with the use of only one skiagraphic control.

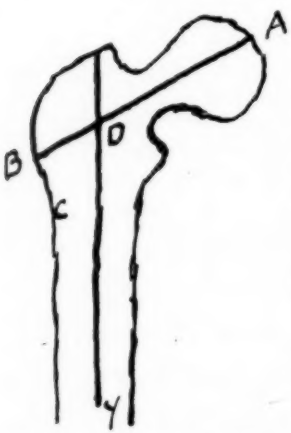


FIGURE I. A-B = axial length; B = point of entry of nail; A-D-Y = angle of inclination; A-B-C = practical angle.

The placement of any fixation medium in the fractured femoral neck is a piece of precision work dependent upon certain dimensional data which the surgeon should be able to determine.

A correct estimation of these will enable him to answer the three plain questions which confront him: (i) What is the length of the nail or nails to be used? (ii) At what point in the femoral shaft must they be entered? (iii) In what direction must they be guided?

The relevant data were estimated on a number (37) of femora, and the results will be set out as this short paper proceeds (see table at page 370).

The result of investigation showed that no reliance could be placed on the figures except as a general guide. They varied so widely that an estimation must be made in every individual case.

## THE LENGTH OF THE NAIL AND ITS RELATION TO THE AXIAL LENGTH.

The line joining the apex of the head and the outer surface of the femoral shaft measured in the central axis of the neck has been named the axial length. It was found in the series examined to average 10·03 centimetres (Figure I).

If a nail of given length is driven a short distance into the trochanter in the plane of the neck and a radiograph of the part is taken, the actual axial

[1] Accepted for publication on June 16, 1939.

length can be estimated in terms of the following formula (Figure II). If A = the actual nail length, if B = the length of the nail shadow, and if Y = the length of the axial length shadow, then X, the actual axial length, $= \frac{A \times Y}{B}$.

The nail chosen for fixation should be of a length a few millimetres less than that of the axial length, since care should be taken not to allow the nail point to project into the femoral articular cartilage. The latter is an avascular structure ill-fitted to deal with a foreign body. To have the nail point pass

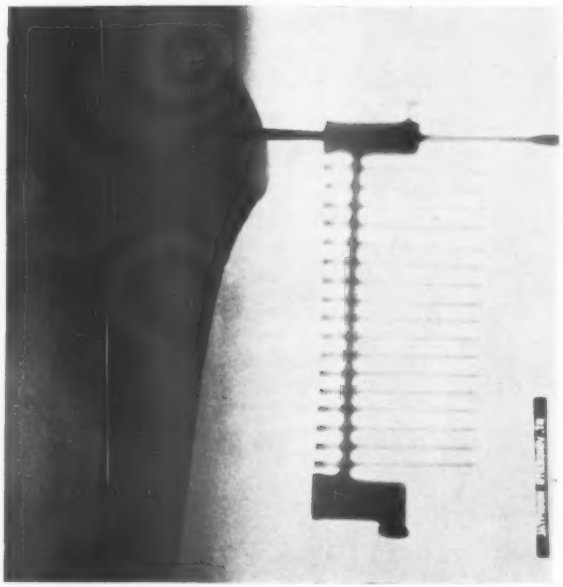

FIGURE II. Apparatus to determine point of nail entry affixed to side of limb by nail 10 centimetres in length driven into great trochanter. The radiogram has been taken after the fracture has been reduced and the apparatus nailed in place.

beyond this plane and enter the acetabular articular cartilage is to cause widespread scarification and damage to the latter on movement at the hip joint, and constitutes a gross technical error.

## THE POINT OF ENTRY OF THE NAIL.

The point at which the central cervical axis meets the lateral femoral surface is called the axial point. In the investigation the distance between this point and the tip of the great trochanter was measured, and the average obtained, called the axial distance, was found to be 6·01 centimetres.

The figures varied too widely, however, to make the result a reliable guide to the axial point, and a direct method of finding the latter was elaborated. Briefly this consists in fixing directly to the femur and parallel

to its long axis an apparatus which in effect is a series of Kirschner wire guides. It is an easy matter to determine from an examination of the skiagram which of the guides is opposite the axial point. A Kirschner wire passed into the bone through the appropriate guide indicates the level of the axial point when the bone is exposed (Figure II).

The nail used to secure the apparatus in position is 10 centimetres in length from tip to neck and serves as the guide to estimate the axial length.

TABLE I.

| Specimen Number. | Practical Angle. A. | Axial Distance in Centimetres. B. | Axial Length in Centimetres C. | Vertical Diameter of Neck in Centimetres. D. | Antero-posterior Diameter of Neck in Centimetres. E. | Diameter of Head in Centimetres. F. |
|---|---|---|---|---|---|---|
| 1 | 118° | 5·6 | 9·3 | 3·0 | 2·1 | Damaged |
| 2 | 130° | 7·6 | 11·0 | 3·4 | 3·0 | 4·5 |
| 3 | 113° | 5·7 | 11·0 | 3·3 | 2·3 | 4·6 |
| 4 | 129° | 6·2 | 10·5 | 3·7 | 2·4 | 4·4 |
| 5 | 128° | 7·3 | 11·0 | 3·5 | 2·7 | 4·9 |
| 6 | 127° | 6·1 | 11·1 | 3·6 | 2·3 | 5·0 |
| 7 | 115° | 5·4 | 9·8 | 3·1 | 2·3 | 4·6 |
| 8 | 118° | 5·8 | 10·6 | 3·6 | 3·0 | 5·1 |
| 9 | 121° | 5·2 | 9·0 | 2·6 | 2·1 | 3·8 |
| 10 | 128° | 5·8 | 9·7 | 3·2 | 2·3 | 4·4 |
| 11 | 112° | 5·3 | 10·3 | 3·5 | 2·8 | 4·9 |
| 12 | 112° | 4·6 | 9·8 | 3·0 | 2·5 | 4·4 |
| 13 | 115° | 5·8 | 10·5 | 3·3 | 2·5 | 4·8 |
| 14 | 131° | 5·9 | 9·7 | 3·1 | 2·6 | 4·8 |
| 15 | 110° | 5·4 | 9·7 | 3·1 | 2·9 | 4·7 |
| 16 | 116° | 5·6 | 9·6 | 3·6 | 2·8 | 4·8 |
| 17 | 125° | 5·6 | 9·3 | 2·9 | 2·6 | 4·4 |
| 18 | 115° | 5·0 | 9·3 | 3·3 | 2·4 | 4·5 |
| 19 | 123° | 7·3 | 11·2 | 3·2 | 2·7 | 4·9 |
| 20 | 130° | 4·9 | 9·1 | 2·5 | 2·0 | 3·9 |
| 21 | 120° | 6·4 | 10·2 | 3·5 | 2·9 | 4·7 |
| 22 | 130° | 7·7 | 10·7 | 3·6 | 2·8 | 5·2 |
| 23 | 124° | 6·1 | 9·8 | 3·3 | 2·7 | 4·7 |
| 24 | 122° | 5·5 | 9·5 | 2·8 | 2·3 | 3·9 |
| 25 | 120° | 5·8 | 10·3 | 3·1 | 3·0 | 4·6 |
| 26 | 118° | 5·8 | 10·0 | 3·5 | 2·8 | 5·0 |
| 27 | 122° | 6·2 | 10·6 | 3·5 | 2·8 | 4·7 |
| 28 | 127° | 6·0 | 9·1 | 2·6 | 2·2 | 4·1 |
| 29 | 118° | 5·0 | 10·1 | 3·8 | 2·4 | 4·5 |
| 30 | 118° | 5·9 | 9·3 | 3·1 | 2·8 | 4·9 |
| 31 | 120° | 5·9 | 11·1 | 3·8 | 2·8 | 5·0 |
| 32 | 121° | 5·7 | 9·8 | 3·4 | 2·5 | 4·6 |
| 33 | 122° | 6·0 | 10·1 | 3·4 | 2·5 | 4·7 |
| 34 | 128° | 6·7 | 10·5 | 3·5 | 2·6 | 5·1 |
| 35 | 117° | 5·6 | 9·5 | 3·3 | 2·5 | 4·8 |
| 36 | 115° | 5·8 | 10·6 | 3·6 | 2·8 | 5·1 |
| 37 | 123° | 5·2 | 8·7 | 2·7 | 2·1 | 4·0 |
| Average .. | 121·1 | 6·01 | 10·03 | 3·2 | 2·5 | 4·63 |

The axial point is the guide to the site of entry of the nail (Figure II). If the Smith-Petersen type is used, then the nail should be entered at the axial point. When, as I believe to be desirable, two ordinary type nails are used, they should be driven one a little above and the second a little below the axial point.

It is important in estimating the length of the nails to remember that the distance each will traverse is a little less than the axial length since the head is oval in outline.

## DIRECTION OF THE NAIL.

To guide the nail accurately it is necessary to have determined correctly certain angles in relation to the neck. Some consideration was given to the question of these angles. They are four in number.

(1) The angle of inclination. This is the anatomist's angle, and is formed by the intersection of the central axis of the neck with that of the shaft. It is usually estimated as averaging 125° to 130° in the adult (Figure I).

(2) The practical angle. This is a term coined for the angle formed between the central cervical axis and the lateral surface of the femoral shaft. It was measured in the series investigated and found to average 121° (Figure I). In certain cases it will be found to be identical with the angle of inclination, but where the lateral trochanteric surface of the shaft is flared out it may vary from the latter by 10° to 15°. These angles can be readily estimated from a study of a skiagram of the sound side, taken with the limb medially rotated, and I have devised a guide which permits of the nail being accurately entered at the correct angle (Figure III).

(3) The outer angle of declination or the torsion angle. This is formed between the central cervical axis and the transverse axis of the femoral shaft. This was not estimated, and the only figures I have been able to obtain are those quoted by Jones and Lovett from the University of Harvard, and are given as varying between 0° and 12°. This angle is of no interest to the surgeon once the alignment of the fractured neck has been restored.

FIGURE III. Nail guide screwed to femoral shaft; first nail has been started and is ready to be driven home; guide is then adjusted for passage of second nail.

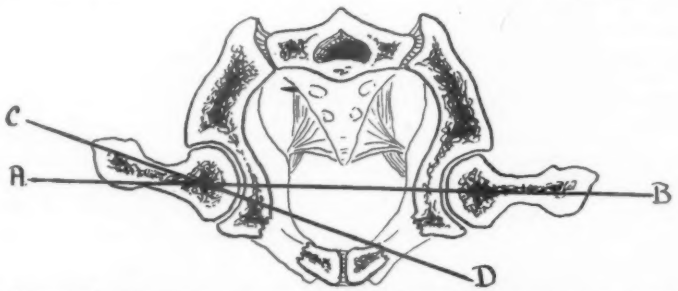


FIGURE IV. Represents a horizontal section through the pelvis at the level of the acetabula. AB = interacetabular line; CD = line of right central cervical axis, showing on this side the inner declination angle. On the opposite side the femur has been medially rotated, bringing the central cervical axis into the plane AB.

(4) The inner angle of declination. I have not been able to estimate this angle, nor do I know of any previous reference to it by any writer on the present subject. It is formed between the central cervical axis and the transverse axis of the pelvis in the interacetabular plane (Figure IV). It is a very important angle, since it is under the control of the surgeon and varies as the limb is medially or laterally rotated. By a very fortunate circumstance it seems almost axiomatic that this angle is reduced to zero when, with the patient lying flat on his back, the limb is fully medially rotated. The central cervical axis is then parallel with the horizon and by the use of a simple plumb bob the direction of entry of the nail can be accurately controlled in this plane.

FIGURE V.

Whilst these considerations provide the chief dimensional factors in the work of the surgeon, there are a few others which are worthy of note.

The minimal diameter of the femoral neck in the antero-posterior direction lies at the base of the neck. It was measured in the series and found to average 2·5 centimetres.

The minimal diameter in the vertical plane is found just distal to the head and in the series was found to average 3·2 centimetres.

It seems clear from a consideration of these figures that great accuracy in placement is necessary and that when the Smith-Petersen nail is being used great care must be taken so to guide it that it does not encroach upon the cortical bone or even the actual joint. It is also clear that the use of more than one nail of this type will cause extensive bone damage, and in any event is to be strongly deprecated.

The diameter of the head was measured and found to average 4·63 centimetres. No consideration of any importance, however, would seem to arise from this estimation, except that the disproportion between the diameters of the head and neck may deceive a surgeon into feeling that because any nail lies well within the compass of the head, all is necessarily well with its course through the neck.

I should like to stress a few general considerations whilst dealing with this subject. The first and most important is a recognition that internal fixation is merely a means of splinting and that as in all fractures the surgeon's work is not done when the splint has been accurately applied. He

has merely taken the first and very important step to ensure the final result of bony union and restoration of function.

I regard as essential the use of such supplementary external fixation as will permit of easy, frequent and comfortable mobilization of the patient and relieve as far as possible any strain on the stability of the splinted part, whilst allowing the limb to be actively moved under controlled conditions.

The question of stability is an important one. Whilst there can be no denial of the intrinsic rigidity of the Smith-Petersen nail, it has to be remembered that this quality depends for its effectiveness upon the equally important tenacity with which the nail is gripped by the bone substance.

This affair of stability is a mutual one; the nail grips the bone, but equally the bone grips the nail, and the strongest pin becomes as the weakest when its own inherent immutability reacts adversely on that of its embracing medium.

For this reason I believe that two nails of the ordinary type, slightly resilient in face of any adverse strain, are less likely to cause damage to the bone, whilst giving a degree of fixation adequate to promote bone union (see Figures V and VI).

FIGURE VI.

These show the final result in the case of a vigorous young man. He has complete bone union with full normal function of the whole limb. His only departure from normal is a few degrees of limitation of medial rotation at the hip joint. He was very difficult to control since he combined a restless, energetic disposition with a fondness for alcohol and he completed his convalescence at his ordinary work of delivering ice from a cart. His union actually occurred under these conditions. It will be noted that one nail has been partly extruded and that both are bent, union proceeding in spite of this with a minimum of displacement and no bone destruction.

I regard it as very doubtful whether under similar conditions a Smith-Petersen nail would have given the same final result.

## ACKNOWLEDGEMENTS.

In conclusion, I wish to express my thanks to Professor A. N. Burkitt, of the department of anatomy of the University of Sydney, for his kindness in placing at my disposal all available material and the necessary instruments to enable me to carry out a very interesting, if not very fruitful, investigation, and to Miss Judith Smyth, a final year medical student, for her excellent drawing (Figure IV).

# ACUTE EMPYEMA.[1]

By F. J. COLAHAN,
*Melbourne.*

THE treatment of empyema as frequently carried out by surgeons not thoroughly conversant with the physiology and mechanics of the thorax and its contents, and often with an inadequate conception of the true pathology of empyema, leaves much to be desired. Too often the patient is discharged from hospital regarded as cured, because discharge has ceased and the sinus is allowed to heal. An attitude of complacency has developed in regard to the treatment of these patients. A brief perusal of hospital records will rudely dispel any misconceptions one may have on the ultimate fate of these patients.

I do not intend to show detailed statistics (so often inaccurate and misleading). The immediate mortality varies from nearly 20% in infancy to 8% or 10% in adults. A comparatively high mortality is inevitable in many cases, as the patient succumbs to the initial infection or disease more frequently than to the complicating empyema. One cannot but be struck with the tremendous morbidity associated with this disease. Patients are admitted to hospital year after year, sometimes several times a year, suffering from sequelæ, the result of inadequate or unsatisfactory treatment during the acute stage of the empyema.

The treatment of empyema must aim at the prevention of these sequelæ—that is chiefly the development of chronic empyema. In other words, we must aspire to satisfactory "healing" of the cavity. Before dealing with the details of such treatment, I should like briefly to discuss some factors vitally concerned with this matter of healing.

Immediately following the withdrawal of any large quantity of fluid or pus from the pleural cavity certain anatomical adjustments take place. Reexpansion of the lung, the shifting back of the mediastinum and the raising of the diaphragm result in a diminution in size and frequently an alteration in shape of the empyema cavity. It may so happen that complete adjustment will at least temporarily obliterate the fluid space. This, however, is not healing of the cavity, which occurs only when complete adhesion between the visceral and parietal pleuræ is established. As this adhesion of the walls of the cavity follows on the conversion of granulation tissue into fibrous tissue, it must be a comparatively slow process. The principles of treatment must be based on this fact, and any procedure which does not achieve this complete obliteration of the cavity is doomed to failure.

The question of drainage is not always the straightforward matter of draining a soft tissue abscess cavity. The most dependent part of the empyema is not necessarily, and rarely is, the most satisfactory drainage site.

The ideal site for establishing drainage is naturally that part of the cavity which shall be the last to "heal" or become obliterated. In practice

[1] Accepted for publication on July 18, 1939.

this is not always an easy matter to attain, and what originally was satisfactory later becomes inadequate drainage. As pointed out by P. R. Allison, if the cavity was a circle and healing occurred at an equal rate from all points of the circumference, the ideal drainage site would be the centre. Usually the cavity is of irregular shape, and healing or obliteration takes place in an irregular fashion and at unequal rates in various parts.

The factors responsible for this unequal rate of healing are the irregularity in shape and the varying degrees of expansibility of the structures forming the walls of the cavity. This difference in elasticity may be in the parietal or visceral walls. The parietal walls may include the ribs and intercostal musculature, diaphragm, mediastinum and vertebral column. One can realize the great difference in expansibility of these components, and how healing will vary when such structures constitute the parietal wall. The visceral wall in like manner will vary according to the expansibility of the underlying lung. Patchy fibrosis of the lung will render parts less expansile than others, with the result that healing occurs at an irregular rate.

Whilst these factors render the choice of the site for drainage difficult, a correct understanding and knowledge of them make it possible to select the most advantageous drainage position.

## CLASSIFICATION OF EMPYEMA.

It is customary to consider two types of empyema: the synpneumonic and the metapneumonic. The distinction is one of importance from the viewpoint of treatment.

The general condition of the patient is important in the treatment of empyema. The metapneumonic type does not begin or is unrecognized till the acute stage of pneumonia is over, by which time the vital capacity has increased. If so desired, these patients can be safely treated by "open" drainage.

The synpneumonic type, following acute streptococcal or influenzal infections, occurs in patients with a low vital capacity, who may be desperately ill, dyspnœic and cyanotic. These patients must be treated, at least primarily, by some form of "closed" drainage.

## THE SYNPNEUMONIC EMPYEMA.

The studies and observations of the Empyema Commission in 1918 (by Graham and Bell) developed a number of fundamental basic principles which still form the foundation of present-day therapy. The one fundamental principle, which is universally accepted, is the avoidance of an open pneumothorax during the formative stages of an empyema. Prior to the investigations of this commission, open drainage in these cases (that is, the streptococcal empyema) before "fixation" had occurred was followed by a mortality as high as 85%. Since the Commission's principles have been adopted a tremendous drop in the mortality and morbidity has occurred. For these cases we have at our disposal two methods of drainage, namely, (*a*) aspiration, (*b*) closed continuous drainage.

### *Aspiration.*

Except in cases occurring as the result of lung abscess, aspiration never does harm in either the synpneumonic or metapneumonic forms. In lung

abscess the risk of "track" infection with spreading cellulitis, due to anaerobic infection, is a very real danger, and this added infection may be sufficient to overwhelm an already dangerously "toxic" patient. As previously mentioned, the presence of pus in the pleural cavity is rarely dangerous in itself—it is rather to the initial infection or pneumonia that the patient succumbs. The treatment of empyema is an urgent matter only when, owing to a large fluid collection, the mechanics inside the thorax are grossly disturbed.

*Amount Aspirated.*—The same fundamental surgical principles apply to the withdrawal of fluid from the pleural spaces as apply to the urinary or biliary systems. In the presence of very large collections of fluid, it is wise to limit the aspiration to 1,000 cubic centimetres. By thus limiting the amount withdrawn, gross mediastinal and pulmonary changes are prevented and gradual decompression is effected.

*Repeated Aspiration.*—Repeated aspiration has the advantage of simplicity, and does not require any special apparatus. With the exception of occasional chest wall infection, it carries very little risk. The disadvantages are that it has to be repeated probably every forty-eight hours, sometimes more frequently, during which time fluid reaccumulates and toxæmia continues. Complete evacuation is seldom achieved. Moreover, there is not the same incentive to lung expansion as occurs with continuous drainage, varying intrapleural pressures operating between the aspirations. If fibrosis occurs at this stage, the lung may never properly expand, and so the "residual space" with chronic infection results. Repeated aspiration very frequently results in a delay of proper surgical intervention. For these various reasons it would appear obvious that the disadvantages far outweigh the advantages, and I am convinced from experience that aspiration, except for diagnostic purposes, is an inadequate and harmful method of treatment.

### *Continuous Closed Drainage.*

The importance of the part played by radiology, both in the pre-operative and post-operative periods, cannot be too greatly stressed. How often is one requested to operate on these patients as an emergency measure, sometimes late at night, without any proper localization having been made! If possible, and only the direst condition of the patient prevents it, a radiograph of the chest should be made prior to any intervention, even aspiration. Aspiration with air replacement, followed by radiographs in two or more planes, then gives us the most valuable information. An exception to this rule is the "total" synpneumonic empyema. These films will show us the position, shape and style of the cavity after the relief of pressure. A good working conception of the elasticity and expansibility of the structures forming the walls of the cavity can be formed, and from this information the most expeditious site for establishing drainage can be gauged.

Closed drainage may be either by (*a*) intercostal insertion of a catheter or (*b*) rib resection with closed drainage.

*Intercostal Insertion of a Catheter.*—It is sometimes considered by the medical attendant that the patient's condition is too desperate to tolerate any surgical intervention. No empyema is too desperate to be drained by the intercostal insertion of a catheter, and the almost moribund, cyanotic

patient will in twenty-four hours appear as a comfortable resurrection. The procedure is simple and can be performed at the bedside, without in any way disturbing the patient. Two or three cubic centimetres of a 2% solution of "Novocain" are injected down to the pleura, and a large thoracic trocar and cannula are pushed through the intercostal space, due precautions being taken to avoid injury to the intercostal artery. The largest de Pezzer self-retaining catheter that can be inserted through the cannula is used; usually a number 24 can be easily passed, when stretched on an introducer. The cannula is withdrawn, and the catheter, having been drawn through a moderately thick rubber sponge to render the tiny wound airtight, is connected either to a water seal or to a negative pressure drainage apparatus.

*Negative Pressure.*—The building up of a definite constant negative intrapleural pressure has very definite advantages over a water seal drainage. It restores to more nearly normal conditions the intrathoracic structures. It promotes drainage and lung expansion, and prevents "fluctuations" within the thorax. The negative pressure should be rapidly raised, so that the lung is kept expanded.

It is necessary that a definite and fixed negative pressure be maintained, and for this purpose either a mercury or water manometer may be connected with the suction jar. After a short initial period of trial the negative pressure can rapidly be increased till it equals 12 to 15 centimetres of mercury. Pressure is regulated according to the needs of the particular case, information being gained by the control radiographs. Excessive negative pressure may occasion pain and hæmorrhagic effusion, which symptoms rapidly subside when the suction is lessened. Decompression can be carried out in the early stages by clamping the catheter and allowing only intermittent drainage till the chest has been emptied of its fluid.

After three to four days lavage may be carried out if so desired, either some antiseptic (Dakin's solution *et cetera*) or saline solution being used. My personal opinion is that it matters little what solution is used—the beneficent effects are mechanical, in so much that the catheter is kept clear by the washing out of thick pus and clots of fibrin. As an alternative to this form of continuous suction, negative pressure intermittent suction may be carried out by the technique of Morelli.

This technique consists in aspiration of the cavity and the injection of a like quantity of antiseptic fluid; this process is repeated till the return is clear, when strong suction by a special syringe is applied and the catheter is clamped. This is repeated daily or more frequently if necessary, and increasing negative pressure is applied, such pressures as 30 to 40 centimetres of mercury being reached.

A very large percentage of these empyemata will "heal" under this method of treatment. My suspicions that the pleura will react favourably and vigorously to infection, if the lung is kept in a state of expansion, have been so far sustained in a series of fourteen consecutive cases.

Repeated X-ray films in the required number of planes will show progress towards healing. If, however, radiological evidence shows that progress is not satisfactory, owing possibly to inadequate drainage (thick pus, fibrin *et cetera*) or to imprisonment of lung in a pleura covered with thick fibrinous exudate, then further intervention, such as thoracotomy, may be needed.

## THE METAPNEUMONIC EMPYEMA.

In the metapneumonic empyema we are dealing with a different set of circumstances. The walls of the cavity are "fixed" and stable, and consequently open drainage, if desired, may safely be adopted. Here again I would reiterate the desirability of preliminary aspiration with air replacement followed by X-ray examination with the patient in the antero-posterior and lateral positions, possibly also in oblique and postero-anterior planes. By no other means can we determine the size, shape and position of the empyema. Drainage done "blindly" without radiological assistance frequently results in the tube's becoming blocked by a raised diaphragm or expanding lung, resulting in inadequate drainage and the development of a residual space.

In the metapneumonic cases there is frequently a heavy deposit of fibrin, also often a thick fibrinous coating over the visceral pleura. For these reasons open thoracotomy is advisable.

At no other time are conditions so favourable for us to procure reexpansion of the compressed lung, and at no other time will the same opportunity be presented to us. Open thoracotomy with resection of three to four inches of rib, performed at the most suitable site, will enable the cavity to be properly inspected and explored. Secondary pockets or sacculations can be effectively dealt with and all fibrinous masses removed from the pleural spaces. Brisk sponging of the visceral pleura may be sufficient to remove the thick deposit, but, failing this, now is the time for deliberate decortication of the lung.

At this stage the thick fibrinous deposit will peel away from the visceral pleura with ease and safety, and at the termination of the procedure it is common for the lung to be almost completely reexpanded. If this opportunity is missed, the conditions are never the same again, and future interventions, besides being much more difficult and hazardous, are not likely to be attended with the same success. Interstitial fibrosis of the lung from within, and spreading from the pleura, is liable to militate against future operations.

This then is the fundamental principle in the treatment of these cases: the thorough cleansing of the empyema cavity and the promotion of lung expansion. The results of our efforts are checked by efficient radiological examinations. The question of "open" or "closed" drainage is more or less a matter of personal preference, as patients will do well under either form of drainage.

After extensive thoracotomy it is sometimes difficult to obtain perfectly airtight drainage, but in the majority of cases by exercising a little care it can be effected. The same advantages apply here to closed negative pressure drainage as in the synpneumonic types, and it has been my experience that convalescence has been hastened and nursing made easier by its use.

It is advisable that a fairly large tube be used, in order that blocking by fibrin plugs will not occur. Lavage can be employed almost immediately (from the second day), due care being exercised to exclude the presence of a bronchial fistula. Syncopal attacks, pleural shock, air embolism resulting even in death, have from time to time been reported, and for reasons such as these it is important that lavage be carried out by the surgeon himself. Provided that no force is used in the injection of fluid and a free outlet is present, there is little or no risk in careful lavage.

The drainage tube should be retained until the cavity is obliterated, and the practice of removing the tube at an earlier time cannot be too strongly condemned.

### *Sulphanilamide.*

The expectations from sulphanilamide used intrapleurally have not been realized. In fact, experimental evidence of the intrapleural use of sulphanilamide would seem to suggest that it is a dangerous procedure.

As in other streptococcal infections, given orally it is of definite value in combating the infection and possibly in limiting its spread. Of the more recent products used for pneumococcal infection I have had no personal experience.

### *General Treatment.*

The empyema patient requires considerable general treatment and supervision. Owing to prolonged fever, sweating and often copious discharge and suppuration, a marked diminution in the plasma protein content occurs and water balance is upset.

A high calorie diet with abundance of vitamins combined with heliotherapy makes all the difference in "boosting" the patient to a winning position.

On that fulminating and very fatal empyema resulting from the rupture of a pulmonary abscess I have not dwelt. This type of empyema is in a class apart, requiring heroic surgery, and is a subject for separate discussion.

In conclusion, the necessity for frequent and satisfactory radiographs should be stressed, and the fact realized that the empyema patient is not merely a subject for blind thoracotomy and drainage, but one whose treatment requires skilled and individual attention.

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# REMOVAL OF THE RETROCAECAL APPENDIX.[1]

By GEOFFREY NEWMAN MORRIS,
*Melbourne.*

THE various positions which may be occupied by the vermiform appendix are well known; the figures given by different authorities as to the relative frequency of these positions vary considerably, and in a general way fall into two main groups which are contradictory.

Wakeley and Gladstone,[1] following an examination of 5,000 subjects, state that the appendix is retrocaecal or retrocolic in 64·38%. Wakeley,[2] in another article based on 10,000 subjects quotes a similar percentage. Collins[3] found 25% retrocaecal at operation and 20% in 4,680 autopsies. Meyer and Spivack[4] state that 9% of appendices were found in the retrocaecal position, while the percentage quoted by Busher[5] and Kelly[6] agrees with those of Collins. In my own series of 105 appendicectomies in the past eighteen months, 16 appendices were retrocaecal.

It is most probable that the discrepancy in the figures results from varying ideas as to the meaning of the term "retrocaecal appendix". A large proportion of the subjects in the series of Wakeley and Gladstone were examined in the dissecting room. Most of the other series quoted were based on operative findings, and the term retrocaecal was reserved for those appendices which were held posterior to the caecum either by adhesions or by virtue of a retroperitoneal position (either behind the parietal peritoneum or underneath the visceral peritoneum covering the caecum) for a whole or part of their length. Those appendices lying behind the caecum but freely movable were excluded; their position is almost certainly not constant.

Marian,[7] in challenging some earlier figures of Lafforgue with regard to the position of the appendix, pointed out that post-mortem positions did not agree with the incidence of abscesses operated upon. He insufflated the caecum and discovered that the position assumed by the appendix depended on the amount of distension in the caecum. He states that the appendix is the most mobile of organs, and with increasing distension the appendix will keep changing its position until finally it points up behind the caecum.

There seems to be little doubt that inflammation occurs more commonly in appendices that are in the retrocaecal position than in those in other sites. Kelly[6] suggests that this is due to an abnormal degree of friction to which the appendix is subjected by contraction of the psoas muscle. Busher[5] says that acute inflammation is three times as frequent in retrocolic and five times as frequent in retroperitoneal appendices as it is in those in other sites.

In the personal series mentioned above every one of the retrocaecal appendices was acutely inflamed and most were gangrenous; though this

[1] Accepted for publication on October 17, 1939.

suggests that inflammation is more common in the retrocaecal position, a possible explanation is that diagnosis of appendicitis is rendered more difficult by the retrocaecal position, so that a longer time interval occurs before operation.

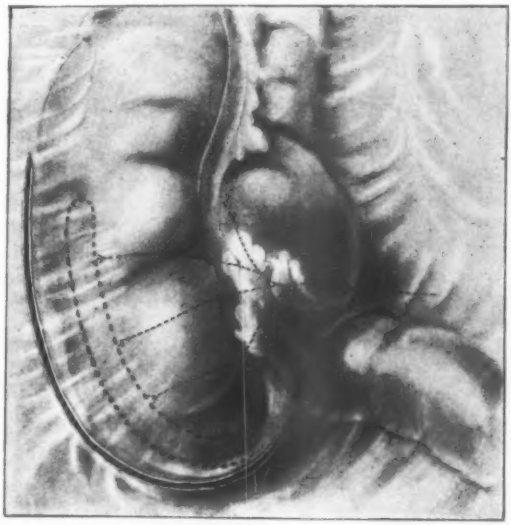

FIGURE I.

Collins[8] is of the opinion that most retrocaecal appendices derive their position from previous attacks, and considers that the only true retrocaecal appendix is one either partially or entirely retroperitoneal or adherent to the posterior wall of the caecum.

The operation of appendicectomy has been stated as being either one of the simplest or one of the most difficult in surgery. Those that fall in the latter category are, I have found, those cases in which the appendix is firmly fixed behind the caecum either by adhesions or peritoneum. The surgical procedure about to be described, though it is not new, is based upon an adequate understanding of the anatomical relationships of the retrocaecal appendix, and has proved of great assistance in the freeing of the appendix in those cases in which the retrocaecal appendix is retroperitoneal for some part or all of its course.

The essential feature of the anatomy of the retrocaecal appendix is that the appendicular artery does not come to the base of the appendix in the manner which is normal when the appendix is in one of the other recognized positions:

FIGURE II.

in these cases it passes as a branch of the posterior caecal artery (itself a branch of the ileocolic) behind the ileum and into the mesoappendix, where the whole vascular supply of the organ can be controlled. In those cases in which the appendix is retrocaecal or paracaecal, the appendicular artery breaks up into its branches, and these diverge to various parts of the organ (Figure I). To control hæmorrhage these branches must be found and clamped; this is especially difficult if the terminal position of the appendix is free and intraperitoneal at the outer side of the colon, where a comparatively large vessel may give trouble in this region—a region most difficult of access.

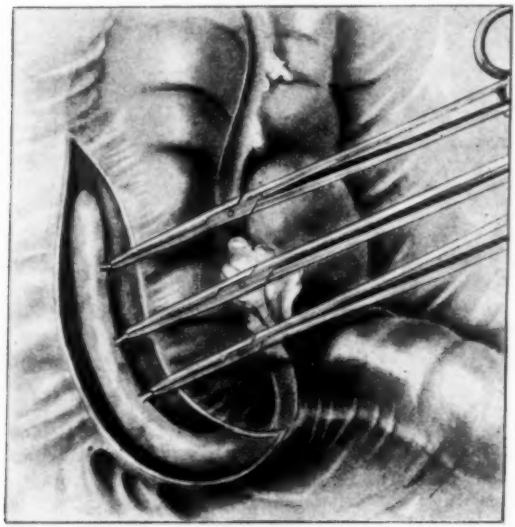

FIGURE III.

The method to be recommended in dealing with the retroperitoneal type of retrocaecal appendix is as follows. Through the McBurney incision, which may be enlarged by splitting the rectus sheath in line with the split in the internal oblique and transverse abdominal muscles, the caecum is found and the appendix is observed to be passing behind the bowel. An incision is made in the peritoneum at the outside of the colon, extending from the region of the base of the appendix up into the paracolic gutter (Figure II). The colon is readily retracted medially, and the appendix is carefully dissected out of its bed. It will be found that difficulty may be encountered in doing this because of the presence of three or four

FIGURE IV.

bands of tissue which bind the appendix medially. These are the vessels which are clamped and cut and the appendix is delivered. The vessels are then tied (Figure III).

The appendix is then clamped, tied and removed, and the stump invaginated if this can be done without trouble (Figure IV). A drain is placed through the loin in the space previously occupied by the appendix (Figure V) and left in position for 24 to 36 hours, when it should be removed to obviate the risk of pressure necrosis of the caecum. It is unnecessary to close the incision in the parietal peritoneum, but this may be done, as a rule without difficulty, if desired. The wound is sutured in layers.

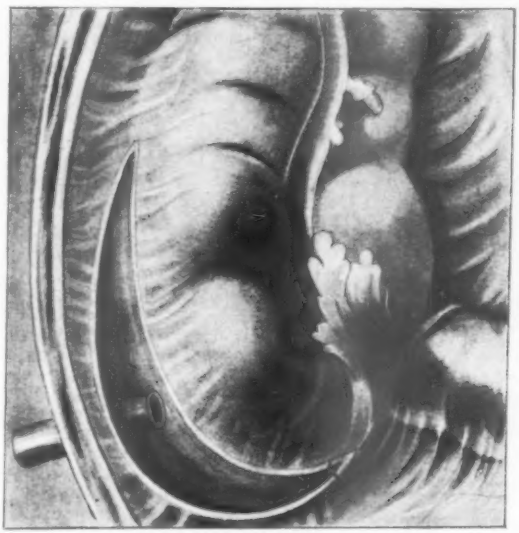

FIGURE V.

It has been argued that in acute inflammation such exposure of the organ opens up tissue planes and predisposes to cellulitis. Several arguments can be brought to counter this objection:

1. A natural morphological plane is opened up, and in ordinary circumstances infection would spread in this plane anyhow.

2. There is far less injury to the tissues than when the appendix is "grubbed out".

3. Control of bleeding reduces the probability of a post-operative hæmatoma, which is a most important factor in the control of post-operative infection.

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## Surgical Technique.

# THE TRANSFUSION OF WHOLE BLOOD.[1]

By JULIAN SMITH, SENIOR,

*Melbourne.*

On the advent of war, the interest in blood transfusion, already high, was very much increased. It seemed to the writer that whole blood technique should again enter the picture somewhere, after having for a long time passed into the background in favour of anticoagulant methods.

The writer's first case of whole blood transfusion dates back a quarter of a century, and was successful with the aid of Crile's cannulæ in the artery to vein direct method. Thereafter many devices were employed, including rubber bulb with cannulæ, multiple syringes and so on, and with varying success up to the advent of citrate, when whole blood methods were abandoned.

With the present renewal of interest on the writer's part a search of literature disclosed the fact of a large number of conservatives still using whole blood, and a multiplicity of devices apparently working well enough in the hands of the designers. Some of these have been tried recently by the writer, but it was soon evident that any device incorporating syringes was not the best; so it was decided to exploit the principle of roller compression of rubber tubing introduced by Noel in 1876.

Henry and Jouvelet's machine is also based on this principle, and has been in use in France for some time for arm-to-arm work. Victor Riddell has also used the principle in a simple pump for determining and regulating the flow in the citrate drip method.

The basic principle of both of these pumps is the serial compression by a single roller of a loop of rubber tubing coiled inside a metal cylinder. Figure I, taken from Riddell's article (*The British Medical Journal*, June, 1939), makes this clear. A milking action is set up which forces the fluid contents of the tube onwards in a more or less steady stream. Riddell states that his pump is unsuitable for direct transfusion.

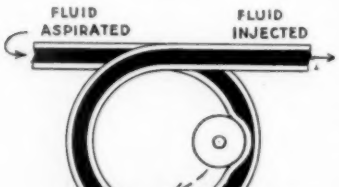


FIGURE I.

A careful examination of the French machine, kindly lent by Major-General Downes, suggested improvements which have given birth to the present design now put forward by the writer.

It will be seen at once (Figure II) that the disadvantageous crossing of the tube on itself has been avoided. This necessitated the adoption of two compression rollers (8), but as a result a very smooth action and a steady flow of blood have been achieved.

Other advantages are: a rapidly acting bench clamp, a detachable revolution counter, the rapid and easy introduction or removal of the tubing, and the ability to boil the whole pump, when this is required.

The essential part of the pump is seen to be a shallow well (Figure II), which accommodates the pressure rubber (1) for about four-fifths of the inside circumference. The remainder of the circumference (Figure III) affords space for entry and exit ports (2) made by oblique semi-grooves in a lug attached to the body. The tubing is secured in place by a plate (3), also correspondingly semi-grooved to complete the ports. Slotted

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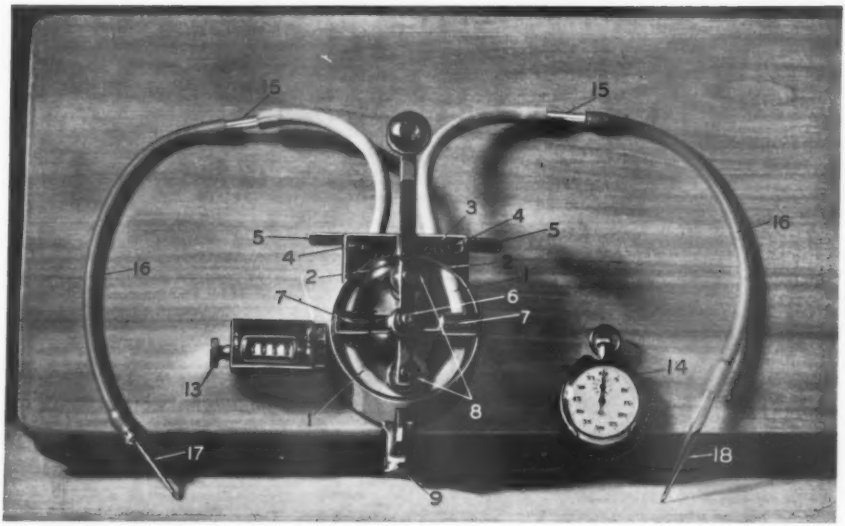


FIGURE II. Showing pump clamped to bench with revolution counter in place, watch clamped to bench and rubber tubing in place ready for use.

pins (4) in the plate pass through the lug and are drawn firmly home by a pair of ramped clamps (5) operating on the underside of the lug by engaging in the pin slots. The centre of the well carries a vertical spindle (6), which passes through the floor of the well to operate a bevel gearing (Figure IV) driving the revolution counter (13), and above carries the handle to which two pairs of rollers are attached (Figure II).

The horizontal rollers (7) facilitate the introduction of the pressure rubber and, later, prevent rising of this tubing out of the well during operation.

The vertical rollers (8) compress the tubing against the inside of the well, obliterate the lumen, and when in action produce a continuous milking effect, pressing forward the contents and continuously drawing more from the source of supply.

The whole instrument is held firmly to the bench by a quickly adjusted clamp (9), the shank of which is thrust through a slotted lug (10) until the screw head (11) strikes the underside of the bench. One turn of the screw levers the shank in its slot and firmly locks the pump in a position about midway between the patients. Figure IV shows the underside of the pump. The small horizontal gear spindle (12) extends up to the middle of three holes drilled through the pump body wall. It is hollow and split at its free end so as to engage in turn one or other of the two revolution counter pins. The remaining pin engages in one or other of the lateral drill holes and keeps the counter rigid. It will be seen that one

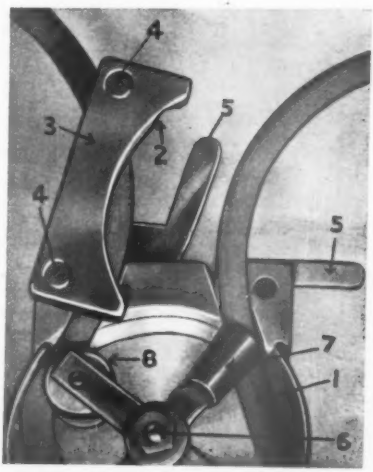


FIGURE III. Showing entry and exit of rubber tubing.

position affords clockwise counting and the other anticlockwise counting; and one or other of these movements will be necessary according to the arm sides of the patients. The counter may be quickly set to zero position by a twist of the knurled head (13) when the transfusion begins.

At the same moment the stop-watch (14) is set in action, starting from zero. This accessory has proved very helpful for the orderly management of the operation. For its safety it is clamped in place close to the pump. The usual time occupied for the transfusion of a pint of blood has been in the region of six minutes.

The blood system of the apparatus, which is the only part that need be sterilized, is made up of: (i) About eighteen inches of the ribbed red rubber tubing (1) now in general use on stethoscopes. It is three-eighths of an inch in diameter and of a bore that delivers one ounce of fluid for each ten revolutions of the pump. (ii) Two glass unions (15) about two and a half inches long which join the pressure tubing just mentioned to two nine-inch pieces of easily compressible transparent or other rubber

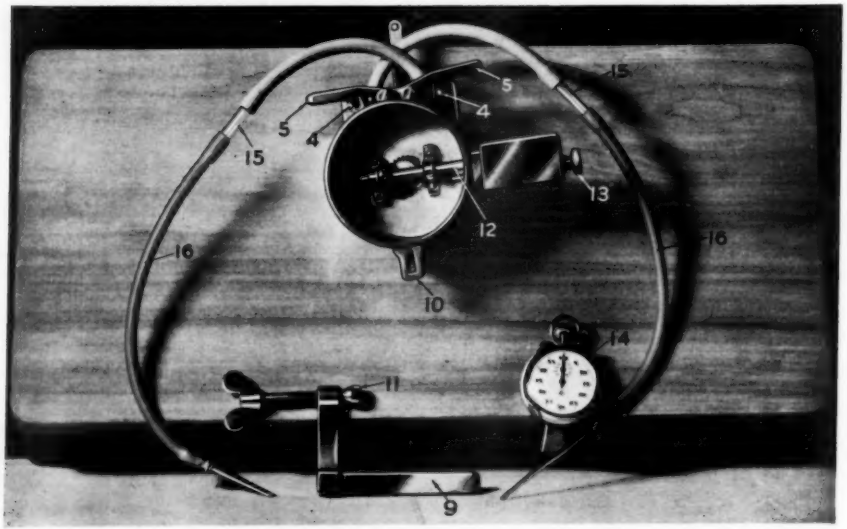


FIGURE IV. Showing underside of pump with bevel gears driving revolution counter.

tubing (16). (iii) The needle (17) and cannula (18) inserted into the free ends of these. The capacity of this system is about half an ounce and not much more than this represents the total amount of normal saline solution transfused during the operation.

### The Bench.

The bench (Figure V) consists of a piece of board about an inch thick and nine by eighteen inches in size. Fixed across it below near each end are two blocks, three by one and a half inches thick and nine inches long. To the underside of each of these are attached pairs of "T" hinges. The free ends of each pair are joined by a cross bar. The pairs fold towards one another in transport, but are opened out in use, and are thrust beneath the bedding supporting donor and recipient. It is clear, therefore, that the tables, beds or stretchers supporting the two are roughly eighteen inches apart, and in this space the operator and assistant stand or sit, one on each side of the bench. A fracture board or a small table with projecting edges may act as a substitute. Attention is drawn (Figure V) to the vessel clamped to the bench. It is sterilized and is designed conveniently to hold the saline solution. Its top is level with the bench; it is

out of the way, it cannot be upset, and yet most readily accommodates the needle and cannula with the ends of attached rubber tubing of each.

Some study has been made of arm compressors. The blood pressure type has been adopted, but the width has been reduced to two and a half inches. That of the donor has the "Tycos" indicator and a trigger release bulb. That of the recipient is rather more loosely applied and is connected by tubing to a small flat oblong rubber bag resting between two pieces of three-ply of the same size and hinged together at one end. This bag is loosely inflated. Foot pressure at the right moment brings about compression of the recipient's arm. Release is instantaneous on removal of foot pressure.

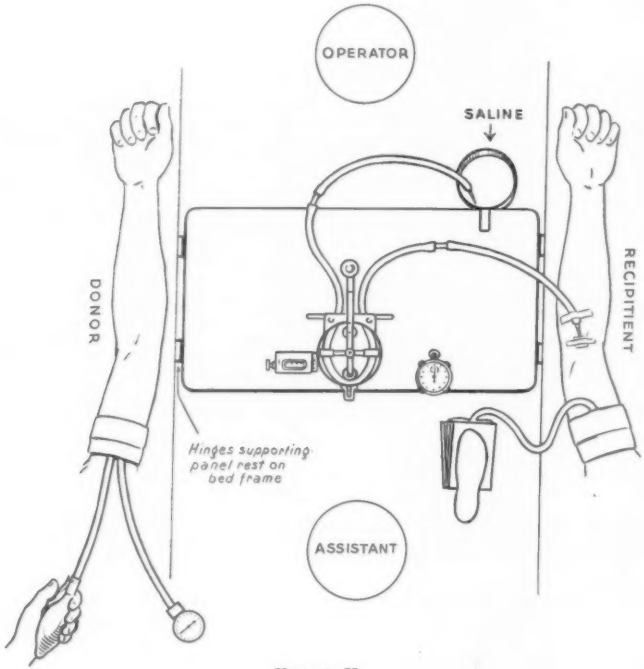


FIGURE V.

It has been found that occasionally even this narrow air inflated compressor gets in the way in the case of donors with short and bulky arms; in these the flat rubber band tourniquet has been applied sufficiently tightly to engorge the veins without obliterating the radial pulse.

### The Operation.

The patients are placed in position close to the bench with the arms drawn only sufficiently away from the side to give easy access, and must be moved cranially or caudally until the bend of the elbow is close to the corresponding corner of the bench, and tests are made to show that the tubing will reach in easy curves to the required positions (Figure V). Supports made of folded towels may be necessary, placed behind the elbows. When the compressors are in place the arms are covered by sterile towels, except at the elbow regions, which are now sterilized. A sterile towel is laid entirely over the bench, and the pump, watch and saline solution pot are clamped in place over it.

The tubing system, already sterilized, is taken from its canister and introduced into the pump. Just before drawing the clamps (Figure II, 5) into place, it is necessary for the best working of the pump to draw on the pressure rubber so that it comes away from the well wall somewhat and does not fit accurately to the circumference. This manœuvre prevents mounting of the rubber tube within the well. The free ends of the soft rubber are now placed beneath the surface of the saline solution, and the pump is put in operation until all the air is replaced by the solution. The cannula and needle are now attached in turn; meanwhile the air in them is expelled by appropriate pump action. Practice on the pump is advisable until the correct direction of turning becomes automatic. The cannula must now be introduced into the chosen vein of the recipient by cutting down. In several of the cases in the present series it has, however, been possible to introduce a needle. Nevertheless it is unwise to spend much time on such attempts. The cannula should be introduced, and, with the donor's needle still beneath the saline solution, a few turns of the handle will flush the cannula clear of blood and prove satisfactory entry into the recipient's circulation. Meanwhile the donor's compressor is suitably inflated and his veins are becoming distended. The pump is stopped. The needle is lifted from the saline solution carefully so as to avoid compression of the tubing, and is pushed beneath the skin. The pump is now turned a little. This causes the donor's tubing to collapse. Onward or other pressure of the needle is now made until this collapse suddenly disappears as the vein is entered and the blood begins to flow. The needle is then fixed in this position by adhesive tape or held steadily throughout by the operator. The handle now at once is steadily turned, a careful watch being kept on the donor's soft rubber tubing. Should this show signs of collapse, the handle should move more slowly, but it should never stop.

Meanwhile readjustments are tried on the air pressure in compressor and the donor's muscle action is varied. With this exception, the handle may be turned easily and at a rate, with the stop-watch as a guide, so as to arrive at a delivery of two hundred revolutions in about six minutes.

It should always be remembered that the rubber tubing attached to the donor's needle must be easily collapsible. It is in fact the manometer of the machine. If its wall is too rigid and if at the same time delivery of blood from the donor's vein becomes slow, the pump may create too great a negative pressure without inducing the tube-collapse warning. In this case there may be a tendency, when the vein is superficial, for tiny air bubbles to be drawn through the skin puncture, thence into the needle and ultimately to appear at the glass union.

Some recent specimens of transparent rubber have, when tested, not collapsed until subjected to a vacuum of 18 to 20 inches, and have therefore not been used. A tubing which, when new, collapses at 10 inches of vacuum, is quite safe. Ordinary number 10 opaque red rubber drainage tube has proved satisfactory. In any case, this complication cannot arise when cutting down on and canalization of the donor's vein have been adopted.

The difficulties met with so far have been as follows:

1. Delay in location of recipient vein. This is met with in grave anæmias with a deep paniculus and when several previous transfusions have been carried out, the readily accessible vessels having thus been put out of use.

2. Donor's needle. It is not intended to discuss here in detail the technique of vein puncture of the donor. Each operator will have acquired the methods and apparatus that suit him best. The donor, however, must have good veins and the correct temperament. There must be a sure entry into the vein and a generous delivery of blood without delay. Failure to achieve this has proved to be the chief difficulty when difficulty has arisen. It may occur at the beginning; or an established flow may cease prematurely. In one case stoppage occurred despite manipulation when eleven ounces had been given. More blood was required. The donor needle was withdrawn and a dressing applied. The tubing was removed from the pump and disconnected from the recipient's cannula, which was temporarily left in place and covered by a pressure swab. A fresh set of tubing was unavailable at the moment, so the blood-contaminated unit was taken apart and thoroughly cleansed with cold water under suction flushing and manipulation, followed by soap and water and in turn by clear water. Fresh needle and glassware were introduced and the whole was sterilized by boiling. The donor was reversed and the other arm was brought under action. The tubing was again introduced into the pump and refilled with saline solution, the old cannula was withdrawn and the fresh one inserted in the recipient's vein, the donor's new vein was

punctured and fourteen ounces of blood were transfused, making twenty-five in all. The second run occupied four minutes and no clotting occurred. It is wiser, however, to have in reserve a supply of tubing sets for emergencies.

In point of fact, in cases in which cutting down has permitted cannula introduction into the donor's vein there has never been any difficulty. It is difficult to imagine a failure. The flow has always been steady and sufficient.

As already shown, a good donor need not be discarded because of a first failure. It is possible to try another vein in the same arm or to change over to the other arm. Once, however, in this series, a donor's veins after several attempts proved unsatisfactory. The blood-contaminated needle was then removed and the tubing was inserted in the saline solution and left for two hours until a fresh donor was procured. Meanwhile an occasional turn was given to the pump to flush the cannula of the recipient, and in due course a pint was transfused with the original tubing in place.

### The Team.

Like everything in surgery, teamwork gives the best results. A full team consists of an operator, an assistant and an instrument nurse or dresser. Though the theatre is a comfort, many of the patients have been transfused in the ward on adjacent beds, often at night with the aid of a hand lamp only. In several cases the operation has been carried through by an operator and nurse only. In these the operator attended to canalization and needling, and the nurse swabbed, handed instruments and turned the pump. The nurse or dresser should study the technique and be readily familiar with all requirements. The assistant has sometimes more conveniently canalized the recipient, leaving the operator free to needle the donor, and then has turned the pump whilst the operator held the donor needle throughout. Then again the operator may needle or canalize the recipient and may change over to the reverse side of the bench in order more conveniently to needle the donor's vein.

Although the team of three persons is the most comfortable arrangement, a moderate amount of experience on the part of operator and orderly will most certainly permit a reduction to two in personnel.

Someone will be required to attend to the donor's arm compressor, and in default a tourniquet must suffice. Where a high degree of surgical asepsis is called for, the pump is boiled and gloves are worn and discarded at the correct moment when changing from attention on the recipient to the donor.

### Preparation of Tubing and Glass.

Now it is very important to give the most rigid care at all times to the lining walls of the tubing, the glassware and the needles. New tubing must be scoured through with a 5% solution of caustic soda. This is followed by a neutralizing flush of a 1% solution of hydrochloric acid, and this in turn by water and finally freshly distilled water. The glass is treated with chromic acid solution and then flushed clear of this with distilled water. The needles should preferably be of stainless steel, the channel highly polished and all shoulders and crevices eliminated. Ideally, no tubing should be used more than once, but in practice it has been possible to use it thrice, provided that thorough decontamination is carried out immediately after use with cold water, soap and water, water again, and finally distilled water. The glass should be cleansed in the same way and finally treated with chromic acid and distilled water. The needles should be flushed and cleansed with the stylet in the same way as the tubing and finally dried out and repolished with rouge or similar powder on a linen cord. The autoclave rapidly deteriorates rubber, so that boiling may be preferable if supplies become short. Some variation in the outside diameter of the pressure tubing is permissible if the ribbed stethoscope rubber is not available, so long as the pump rollers completely obliterate the lumen when in action. Naturally if the bore differs from the standard the pump may be easily calibrated, but with any particular bore the output per revolution is quite constant.

### Blood Grouping.

No special precautions were necessary for the blood grouping of this series. The patient has been typed and a suitable relative or a service donor chosen and then a last minute direct matching test has been made. No reactions at all have been observed. All types of patients needing transfusion have been treated, ranging from the acutely

exsanguined on the one hand to the chronically and gravely anæmic on the other. In no case has the rapid transfer of blood appeared harmful to either donor or recipient. On the other hand, no case of *morbus cordis* was included.

Speed shock has been mentioned as an objection, but it is difficult to imagine this occurring in the war wounded in need of resuscitation.

Apart from this speed "shock" as a supposed objection, the possibility of disease transmission has been urged. The reply is that there is always time for a reasonable questioning and examination of the donor, but beyond that, where the matter is very urgent, the risk must be taken as a life-saving manœuvre. The risk to the donor in cases of septicæmic recipients can be avoided by the correct surgical observances.

Psychological difficulties in either donor or recipient due to proximity of the other have not occurred in this series.

Direct transfusion is not practicable during an operation, but may of course be used immediately before or after the event.

Another objection raised is that arm-to-arm technique is difficult. In reply it may be said that it requires very little study to become accustomed to the correct arrangement of the patients, and to the emplacement of the bench, and of the items clamped to it. The handling of the pump during use becomes automatic after very little practice. The entry to the recipient's vein may be deliberate and is easy; but the entry to the donor's vein is sometimes a matter requiring practice and skill, and from this moment until the termination of the transfusion, special alertness becomes important. When, however, cutting down on and canalization of the vein are permitted, the main difficulty vanishes.

Quite recently the new pump has been used in two metropolitan hospitals by enterprising house surgeons without difficulty.

After reviewing the recent experiences, the writer feels confident that those workers undertaking resuscitation as a routine would have no difficulty whatever in transfusing a pint of whole blood in less than six minutes of running time.

But by far the most serious theoretical objection to whole blood transfusion is the possibility of clot transference to the recipient. The trouble, if it occurs, cannot be common, for it escapes notable mention in literature. Blain in America quotes a series of 3,000 cases of transfusion of unmodified blood without reference to it, and Brines, in speaking of over 2,000 of the same series, says: "As far as I know, embolism has never been produced during a transfusion given by my associates or me." In the present short series there has been no evidence of it. For example, one patient with aplastic anæmia had ten whole blood transfusions within nine months, and is now quite well. Several others in the series are still under similar treatment. Each, having had numerous transfusions, becomes a critical indicator upon this question, and none of them shows any sign, early or late, of embolic influence.

In an endeavour to clear up the matter a few experiments have been made.

In one instance a patient with hyperpiesis was in need of blood-letting. The blood was drawn from the forearm by needling and pump action; the cannula end of the circuit fed the blood into a suitable citrate solution. The rate of turning was slowed down purposely, so that a full 20 ounces were drawn in thirteen and a half minutes. The blood was still running freely. Rapid examination of the tubing disclosed some adherent clot in it, but nothing was found in the citrate solution, after being strained through muslin, beyond a few filamentous thrombi of sewing cotton size and under an inch in length.

Another patient with polycythemia *plus* hyperpiesis was treated by blood-letting, but on this occasion the total run of one pint of blood was made through the pump in six minutes. Most careful examination failed to detect any evidence of thrombus in the citrated blood.

The great advantage of the pump is that the transfusing stream never stops, and therefore stagnation, which hastens clotting, is avoided.

The writer acknowledges with gratitude the full-time collaboration of Dr. John McLean, whose patients suffering from hæmatological conditions at the Alfred Hospital have been given whole blood transfusion during the period of work on the development of the pump. Acknowledgement is also made to Mr. Lawrence Hansen for his capable engineering work in carrying out the author's requirements.

It may be of interest to quote a few instances from the present series of over sixty transfusions in which the rotary pump has been used by the writer and Dr. McLean.

1. A man of fifty-two years of age, suffering from serious recurrent hæmorrhage and a hæmoglobin percentage of 32, was given three transfusions within four days. One each occasion twenty-five ounces were given. The donors were relatives. Two were needled and the transfusion was finished well under the six minutes. The third had very poor veins and permitted cutting down. He gave twenty-five ounces through a glass cannula in a few seconds short of five minutes and showed no ill effect. This patient did very well. His hæmoglobin percentage was over 70 within a week. The hæmorrhage ceased.

2. The largest amount given in the series was thirty ounces. The donor was a relative and the condition very serious. Cutting down was permitted. Transfusion time was seven minutes. The donor showed slight blanching and smallness of pulse without rate increase and recovered soon.

3. A woman, aged forty years, suffering from hæmatemesis, had on admission 40% hæmoglobin, and was given one and a half pints of citrated blood. On the second day the hæmoglobin percentage was 46; on the fourth day the hæmoglobin percentage was 30, and one pint of citrated blood was given. On the fifth day the hæmoglobin percentage was 28 and the patient, who was still bleeding, was given two and a half pints of citrated blood. On the sixth day the hæmoglobin percentage was 50; on the seventh day it was 45; on the eighth day 28. On the ninth day the patient was given one and a half pints of citrated blood. On the tenth day the hæmoglobin percentage was 45; on the eleventh day it was 35, and the patient, who was still bleeding, was given one pint of whole blood in seven minutes from a Group IV donor, the patient being in Group II. No further bleeding occurred. On the sixteenth day the hæmoglobin percentage was 60, and fourteen days later it was recorded as 85.

The question as to whether whole blood is "better" than citrated blood is still *sub judice*, but a review of this short series of cases leaves a strong impression in the writer's mind that, if hæmorrhage continues or recurs after the use of a reasonable amount of citrated blood, a change over to whole blood is quite worth while. A point perhaps worth noting is the personal reaction of observant recipients who have undergone multiple transfusions by both the citrate method and by whole blood. Many have volunteered the opinion that they feel more refreshed after whole blood transfusion.

## Summary.

1. An improved arm-to-arm transfusion device is offered which provides for a continuous stream and avoids other disadvantages associated with syringes.

2. It is possible in a high percentage of cases to transfuse a pint of blood within six minutes of running time.

3. If cutting down on and canalization of donor's vein are permitted, the operation is easy and always successful.

4. The so-called speed shock to the recipient has not been observed.

5. The machine offers excellent alternative uses both as an aspirator and for massive injection of local anæsthetic, and of course in determining the flow and injection of citrated blood.

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## Case Reports.

# TWO CASES OF HUNNER'S ULCER OF THE BLADDER OR INTERSTITIAL CYSTITIS IN THE PRESENCE OF IDIOPATHIC HYPOCHROMIC ANÆMIA.[1]

By Douglas Robb,
*Auckland.*

**Case I: Hunner's Ulcer or Interstitial Cystitis in a Woman with Idiopathic Hypochromic Anæmia and Plummer-Vinson Syndrome.**

Mrs. R.H., aged fifty-seven years, married, with three adult children, had been referred to me in 1934 by Dr. Elaine Gurr on account of fibroid tumours of uterus (at the age of fifty-three). Although the menses had ceased eight months before, she suffered greatly with pains about the left side of the abdomen and left leg and had a feeling of pressure in the pelvis. The bladder was uncomfortable with a similar feeling of pressure, and frequency of micturition was present. These symptoms were all attributed to the uterus, which was the size of a coconut owing to the presence of one large and several small fibroids. The cervix was deeply lacerated. A total hysterectomy which included tubes, ovaries and appendix was performed, and the patient made an uneventful recovery, though she recalls that the bladder was troublesome during the convalescence.

For the next four years the bladder remained troublesome. Repeated urinary examinations by her doctor failed to reveal abnormality, and it began to be suspected that the complaints were of an hysterical nature, for the patient all along had been of a querulous, emotional type. She complained of extreme frequency of micturition, great pain on standing, and particularly on jolting in a motor car or on a hard pavement. Relief from the pain, but not the frequency, was obtained by lying down. She had spent the preceding twelve months mostly in bed. No blood or deposit had been seen in the urine. On further questioning the bladder symptoms were found to go back certainly for six years, and possibly twenty.

On cystoscopy, most of the lining of the bladder seemed normal, but an area was seen reaching from the apex down the postero-lateral wall on the left side which looked like hypertrophic gastric mucosa. The surface of this area was raised, red and corrugated, with no tendency to bleed, and gave the impression of rigidity. Bladder capacity was less than normal, but was not measured on this occasion. The response to the Wassermann test was negative. The nature of the lesion was not recognized at this stage and a suprapubic exploration was advised.

The peritoneum was opened first, but was closed when no extravesical spread or suggestion of malignant disease was found. The bladder was opened and the lesion was demonstrated. A partial cystectomy, with the removal of 0·3 to 0·5 centimetre of healthy tissue surrounding the lesion, presented no difficulty. Convalescence was uneventful, except for severe and painful bladder spasms, which took three to four weeks to pass off.

Dr. E. F. Fowler, pathologist, described the specimen as follows:

"The lesion measures five centimetres by two centimetres. The mucous membrane of this area is thrown into folds, and projects one centimetre above the normal mucosa. The affected part is deep red in colour. Microscopically it shows a marked degree of necrosis. There is extensive hæmorrhage into the mucosa and into the superficial portions of the muscular coat. Throughout the mucosa there are small aggregations of mononuclear cells, including a few plasma cells. There is no evidence of malignancy."

A post-operative diagnosis of Hunner's ulcer or interstitial cystitis was made from the likeness to published accounts of this condition. About a month from the operation the suprapubic wound had been dry for a week, and cystoscopy was repeated to study the scar. The scar was not obvious at all, having healed nicely with a little puckering. Bladder capacity was still diminished, but was not measured. The remainder

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of the bladder lining (previously regarded as normal) was on this occasion noticed to be rather pale, and thickened particularly around the base. The vessels were not clearly defined. These appearances called to mind those in a woman of similar age with hypochromic anæmia whom I had examined with a cystoscope two days before (same patient as in Case II).

Inquiry soon revealed that this patient also suffered from long-standing idiopathic hypochromic anæmia, with dysphagia, sores at angles of mouth, peripheral neuritis, and fragile nails. The result of the examination of her blood by Dr. Fowler is set out in Table I, together with the blood picture after ten weeks' treatment with large doses of iron.

TABLE I.

| — | June 11, 1938. | August 25, 1938. |
|---|---|---|
| Red cells | 4,370,000 per cubic millimetre. | 6,270,000 per cubic millimetre. |
| Hæmoglobin value | 54%—7·8 grammes per 100 cubic centimetres. | 110%—16 grammes per 100 cubic centimetres. |
| Colour index | 0·63. | 0·88. |
| Leucocytes | 4,650. | 4,375. |
| Polymorphonuclear cells | 48%. | 44%. |
| Lymphocytes | 46%. | 52%. |
| Monocytes | 4%. | 4%. |
| Eosinophile cells | 2%. | — |
| Films | Red cells show anisocytosis and poikilocytosis. Numerous microcytes and moderate hypochromia are present. | Red cells show a slight degree of anisocytosis and hypochromia; only a very few microcytes are present. |

After the discovery of the anæmia and the institution of iron treatment, the general condition soon began to improve and the bladder became more comfortable. After three weeks of iron the patient could go for one and a half to two hours without passing water, and though the interval had not been increased after ten weeks' treatment, she felt the bladder greatly improved in comfort. There was no pain at all, but she felt sudden desire to pass water when a certain degree of distension had been reached. She had to empty her bladder very soon after drinking water, and had to get up several times every night. Cystoscopy after ten weeks' treatment showed sudden pain after seven ounces of fluid had been run in. The scar was as described, and the lining elsewhere more closely approached normal. It was pale in parts, a little "soggy" below the scar, but elsewhere the vessels showed clearly. A feature noticed for the first time (it is possible it was missed on the former occasions) was a fringe of tiny fronds of mucosa hanging down from the ventral aspect of the internal meatus. I had seen similar fronds in two other women, in one of whom they required diathermy, which practically abolished extreme dysuria. Neither of these other two has yet been examined for anæmia. The general condition on this last occasion was greatly improved in every way. The neuritis still interfered with walking. Iron was being willingly continued.

A follow-up examination twenty-one months after partial cystectomy was requested, but the patient at that time could not be found.

*Summary.*

This interesting case concerns a woman of fifty-seven years who, looking back, probably suffered from an unrecognized idiopathic hypochromic anæmia for twenty years. During that period, certainly in the last six years of it, she had severe bladder symptoms, without urinary changes, which were recognized to be associated with a tolerably large Hunner's ulcer or area of interstitial cystitis, which was successfully removed by partial cystectomy before the underlying anæmia was recognized. The bladder discomforts were not abolished by the operation, but were diminished, and were further diminished by iron therapy.

### Case II: Hunner's Ulcer of Bladder in a Woman with Idiopathic Hypochromic Anæmia, Plummer-Vinson Syndrome, and a Precancerous Lesion in Buccal Cavity.

Mrs. W.B., aged forty-eight years, was referred by Dr. S. Morrow, of Morrinsville, in June, 1938, on account of a small growth in the mouth which he had removed twice five and four months previously.

The growth took the form of a folded excess of mucosa in the right lower labio-alveolar sulcus opposite the premolar region. The patient said she had seen pus exude from it. The growth was excised with the diathermy needle, and the base of the region was coagulated. Healing was slow but sure, and has remained sound for eighteen months. After histological examination, Dr. E. F. Fowler reported:

"Sections show a marked overgrowth of the epithelium. There is an extensive inflammatory infiltration of the subepithelial tissues, the vessels of which are engorged. There is no evidence of malignancy."

This buccal condition is interesting in the light of Ahlbom's views as to iron deficiency and hypochromic anæmia's being the basis frequently of precancerous and cancerous lesions in the upper part of the alimentary tract, especially in women, and in the pharyngo-œsophageal region.

At the outset cracks were noticed at the angles of the mouth, and brittle atrophic nails. The patient readily confessed to a dry mouth, difficulties in swallowing, a sore tongue occasionally, and tinglings in various parts of her body. Her hair was jet black, but this was found to be due to her own efforts—a procedure which darkened counsel as well as the hair. Dr. J. E. Caughey saw her for me, and kindly gives this account of her condition as a case of anæmia.

"Mrs. B., examined on June 18, 1938. Up until seven years ago she had been able to play tennis regularly, but since that time had noticed she tired very readily and she had been unable to attend to her housework as well as previously. For five years she had had cracks at the angles of her mouth, and the tip and sides of her tongue had been sore. For a year she had noted difficulty in swallowing solids. She had been troubled with abdominal discomfort and a sense of fullness after meals.

"On direct questioning she stated that her hair began to grey at thirty. Her body hair had always been scanty. Her periods had been scanty and irregular for ten years. For a year she had complained of 'pins and needles' in her feet and legs as high as the knees and in her finger tips. She had felt the cold very much for two years. The nails of her fingers and toes were brittle. Her finger nails split and tended to break off at the tips and have to be kept closely cut. For three years she had eaten no red meat or eggs.

"Physical examination: A well-developed, well-nourished woman. Head hair fine in texture and grey. Body hair very scanty and of very fine texture in the axillæ and pubic region. The limbs and trunk are completely devoid of hair. Skin of very fine soft texture with somewhat puffy appearance. There is an underlying yellow tinge and pallor, but a malar flush. Mucous membranes are pale. There is a well-marked perleche and the tongue is small, red and quite smooth and atrophic, there being no papillæ evident. Finger nails are thin, soft, brittle and are longitudinally ridged. No enlargement of thyreoid gland. No lymph node enlargement. Heart and lungs presented no abnormality. Liver and spleen not palpable. There was definite diminution of appreciation of pin prick and light touch in the upper extremities as high as the wrists and in the lower extremities to the middle of the calves. Over the feet 'pins and needles' were induced by light friction. Appreciation of vibration was lost at the ankles and knees. No definite loss of position sense. Deep reflexes were present and equal in arms and legs. Plantar responses were flexor in type.

"Laboratory findings: See Table II. Gastric analysis and inspection of lower pharynx were not carried out.

"The case is thus a characteristic example of idiopathic hypochromic anæmia."

At the first consultation she said she had had a pelvic operation some years before, and that her periods had been absent for three months. Before that there had been flooding. There were no flushes nor other special nervous symptoms of the menopause, though flushes started a few months later, when there were also occasional small losses. On her most recent visit she gave a history of repeated sore throats, and inasmuch as the tonsils were enlarged and exuded yellow material, I removed her tonsils by dissection (December 20, 1939).

The bladder had been a source of much trouble for some five years before she first came. Pain and frequency led her to consult a urologist four a half years before, when she was told she had ulcers in the bladder. Records of this examination unfortunately could not be traced. Catheter urine was acid and showed a trace of albumin. The deposit contained epithelial cells, an occasional red blood cell, a few pus cells and a number of calcium oxalate crystals. No casts were present. In the films pus and numerous Gram-negative coliform bacilli were seen. On my first cystoscopy I thought the bladder mucosa tended towards a sodden appearance, the vessels being obscure. There

TABLE II.

| —— | June 7, 1938. | August 17, 1938. | December 19, 1939. |
|---|---|---|---|
| Red cells | 5,130,000 per cubic millimetre. | 4,740,000 per cubic millimetre. | 4,980,000 per cubic millimetre. |
| Hæmoglobin value | 54%—7·8 grammes per 100 cubic centimetres. | 80%—11·8 grammes per 100 cubic centimetres. | 80%—11·6 grammes per 100 cubic centimetres. |
| Colour index | 0·5. | 0·85. | 0·80. |
| Leucocytes | 6,800 per cubic millimetre. | 5,150 per cubic millimetre. | — |
| Polymorphonuclear cells | 54%. | 36%. | 40%. |
| Lymphocytes | 40%. | 62%. | 54%. |
| Monocytes | 4%. | 2%. | 6%. |
| Eosinophile cells | 1%. | — | — |
| Basophile cells | 1%. | — | — |
| Films | Anisocytosis; poikilocytosis; many microcytes; marked hypochromia; slight polychromatophilia. | Anisocytosis; slight hypochromia; a few microcytes. | Anisocytosis; poikilocytosis; hypochromia; many microcytes. |

were one or two small patches of possible ulceration and possible crystalline deposit. The capacity was 240 cubic centimetres. A few days later when cystoscopy was repeated, Mr. Frank Macky was present, but he could not agree that there was anything beyond the appearances of a patchy mild cystitis. There was a small reddish patch near the left ureteric orifice and other reddish patches were seen. Parts of the lining seemed normal with the usual appearance of vessels.

Two months later, after a good course of iron, her general condition improved, but the bladder remained as uncomfortable as ever. She was up six or seven times at night, and passed urine more often by day. The bladder capacity was 210 cubic centimetres. The urine was quite clear, pale and acid; the findings on cystoscopy by myself were recorded thus: "Sodden appearance of a mucosa pretty general, one or two reddish flares."

Four months later, after a course of sulphanilamide (not tolerated well) for the admittedly slight degree of infection present, her dysuria was as bad as ever. Cystoscopy was not repeated.

Twelve months later, eighteen months after the first consultation, her general condition was slightly better, and although she had been taking iron regularly, her blood still gave a definite, though not severe, picture of hypochromic anæmia. She had spent weeks in bed on account of extreme frequency of micturition and pain. She said she passed pus and blood in the urine, but on examination the urine was clear, no albumin was present and no pus; some mucus was present. The bladder capacity was only 120 cubic centimetres. On cystoscopy I again thought the mucosa had a "sodden" appearance. The ureteric orifices were not greatly abnormal. But for the first time there was a red patch on the lower part of the right lateral wall and extending back to the base behind the trigone, and another on the left side. After the patient recovered from the tonsillectomy, I asked Dr. H. J. Gaudin, Fellow in Urology of the Mayo Clinic, to see the lesion with me and treat it by bladder distension. He writes:

"Under 'Evipan' anæsthesia the bladder was examined with the aid of the Braasch direct vision cystoscope and the following observations recorded.

"The urethra was normal and there was good sphincteric control. The ureteric orifices were visualized and spurts of clear urine noted from either side. The bladder wall generally was rather pale and the mucosa over the base somewhat œdematous.

"Two typical 'salmon pink patches' of interstitial cystitis were observed in the base of the bladder. One on the left situated just lateral to the ureteric orifice was approximately 1·0 centimetre by 1·5 centimetres. The second patch on the right wall close to the bladder base was more linear, extending about 2·0 centimetres forward to the right of the bladder neck.

"With four feet of head of water the bladder was slowly distended, under vision, to 350 cubic centimetres. Extensive splitting of the mucosa occurred at the sites described, the two areas becoming connected by a split across the base of the bladder.

"A moderate amount of bleeding followed. A 18 Fr. soft rubber catheter was tied in the bladder and the patient returned to bed."

The immediate effect of this treatment was good in increasing bladder capacity and diminishing pain and frequency.

*Summary.*

A woman of forty-eight years, at the early stage of menopause, had a precancerous lesion in the buccal cavity. She was found to be the victim of a long-standing hypochromic anæmia with Plummer-Vinson syndrome. She had had pain and frequency of micturition for five years, but not until eighteen months later was a definite lesion found in the bladder, when large patches of interstitial cystitis were found and treated by distension of the bladder.

## Comment on the Two Cases.

In the accounts accessible to me of interstitial cystitis the ætiology is admittedly obscure. The nature of the lesion, the long history and the frequent absence of urinary changes make one think of a trophic condition rather than of an inflammatory or neoplastic one. In both the cases described there are two possible bases for a trophic change.

The first is the menopause. Various parts of the genital tract undergo atrophic changes at this period, and while many factors are doubtless present, the withdrawal of œstrin is probably important. One has only to see the dramatic change for the better in *kraurosis vulvæ* when this hormone is given by the mouth, by injection or by inunction to realize what a valuable metabolic and nutrient material it is. It is possible to imagine interstitial cystitis as a "*kraurosis vesicæ*". In Case I the development of the cystitis took place probably in the last two years of menstruation and even more in the four or five years after it ceased. The presence of fibroids suggests a failure of ovulation and hormone imbalance, and this, as well as the failure of œstrin a year or so before the hysterectomy, may be related to the condition. Treatment with œstrin was not instituted, so therapeutic evidence is lacking. In Case II there is perhaps less ground for invoking this basis, because there were serious bladder symptoms five years before the periods stopped. It must be conceded, however, that the interstitial cystitis developed in the year or so following the cessation of the periods. Treatment with œstrin was given, but simultaneously with iron and nicotinic acid, and recovery from tonsillectomy and also bladder distension, so it is difficult to apportion share in relief.

The other possible basis or contributing factor for interstitial cystitis in both these cases is put forward with slightly more assurance. It is the anæmia. Certain features of this variety of anæmia and of interstitial cystitis are comparable. They occur more in females, and run a chronic course. The incidence according to age is not very different, though the cystitis tends to the twenties and thirties and the anæmia more to the thirties and forties. There is also an analogy between the bucco-pharyngeal changes in the anæmia and the changes described in the bladder in these two cases. Various degrees of malnutrition and atrophy are found in the lips, buccal and lingual mucosa and in the pharynx and at the junction of the pharynx and œsophagus. The mucosa is pale and is inclined to split on stretching, and webs and bands are described. The changes described in the bladder are essentially those of diminishing power of distension due to the atrophic condition of the bladder wall, made much worse when obvious breaches in the mucosa develop. At this point, however, the analogy stops. The buccal changes are recognized to be precancerous (Ahlbom), whereas no one has suggested that interstitial cystitis may lead to malignant disease. I have examined the bladder of several other patients with anæmia who complain of slighter but troublesome bladder symptoms, and found similar diminution in capacity, with soddenness and pallor or mucosa and obscuring of blood vessels. The occurrence of infection in the urinary tract in anæmia, particularly of the macrocytic type, is possibly common, for I know of one case of microcytic and two of macrocytic anæmia in which it was a marked feature. Whether such infection is due to a general or to a local lowered resistance I cannot say.

These suggestions obviously require checking by other observers in clinics with a large volume of material.

## Summary.

Two cases are described in detail in which Hunner's ulcer or interstitial cystitis occurred in middle-aged women who also showed marked idiopathic hypochromic anæmia.

It is suggested that this or other similar nutritional deficiencies may be not unrelated to interstitial cystitis and also to certain less striking changes in the bladder wall, and that further observation may place such deficiency as a factor of importance in the cause of the cystitis.

An analogy is drawn between these bladder changes and the bucco-pharyngeal changes in anæmia.

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# Reviews.

**Surgery of Modern Warfare.** Edited by HAMILTON BAILEY, F.R.C.S.; Part I, 1940. Edinburgh: E. and S. Livingstone. Super royal 8vo, pp. 164, with illustrations. Price: 12s. 6d. net.

THIS volume, the first of four that will be published, deals with general and special considerations of wounds.

The chapters on types of missiles, their location by X rays and methods for their removal call for no comment; the chapter on bacteriological examination is good, as are those on the classification of wounds, delayed primary and secondary suture, and on methods of dressing wounds, although the latter is more applicable to civil than to military surgery. The chapter on skin grafting is unfinished in this volume, and that on anæsthetizing the wounded is not very helpful; the gas machine illustrated seems a cumbersome piece of apparatus for conditions of war.

By avoiding academic considerations Professor Finch has contributed a valuable article on shock and its treatment. Mr. Wakeley has written an excellent chapter on burns, and younger surgeons should heed his statement that "each and every case of extensive or severe burns requires an anæsthetic and a complete surgical cleansing". Only after this should applications of triple dyes and tannic acid be used. The chapter on tetanus is of the high standard which is to be expected from Cole, but we wish that he was more vehement in his denunciation of the intrathecal use of antitoxin. Surely Ransom's statement of 1903 should now be ignored in view of our knowledge of the circulation and functions of the cerebro-spinal fluid.

Naturally, in a work so recently published, our attention is focused on the chapters dealing respectively with what is known as the "closed plaster treatment", with gas gangrene, with transfusion of blood and serum, and with chemotherapy. The local treatment of recent wounds is exceptionally well described by H. H. Sampson, who sets the rather long limit of twenty-four hours as the period that may exist between contamination (coincident with infliction) and infection. He carefully explains the principle that, after excision, tissue support is essential, and that the application of a closed plaster to the wound which has been excised and packed, provides this support. He hastens to add, however, that before such plaster can be used with safety three conditions must be fulfilled: (*a*) wound excision must be complete, (*b*) it must be done within eight hours of the injury, (*c*) the blood supply of the limb must not be in doubt. Seymour Barling, in his contribution on the treatment of infected wounds, likewise advocates the use of closed plaster in cases of quiescent infection, and emphasizes that the only wounds that fall into this category are those with which any experienced surgeon would not interfere because no indications for such interference exist. When unusual tenderness and pain, bruising and œdema, thin foul discharge or a deteriorating general condition exists, surgical interference is essential. Only when comparative quiescence is attained following such surgical measures, should the limb be enclosed in a complete plaster. The principle of complete rest is not new; primary suture of excised wounds would provide tissue support if it were accurate and did not strangle any tissue, but as it prevents all drainage it has been proved to have but little place in the treatment of wounds; packing, together with the application of a complete plaster, provides the necessary tissue support and is undoubtedly superior to open drainage without packing. This is the new development. The closed plaster method is not a panacea and will fail unless the precautions set out are observed.

Whilst the two chapters just referred to might well rank as classical contributions to the treatment of wounds, the article on gas gangrene reads like a synopsis prepared for undergraduates by an inexperienced coach; it is misleading, and the statement that 15,000 units of antiserum are an adequate prophylactic dose reveals this inexperience. The chapter on the treatment of gas gangrene by X rays is unconvincing; there is no real evidence that X rays prevent gas gangrene as defined by the Medical Research Council many years ago, nor that they can cure it; and reliance on this form of therapy must lead, in the genuine cases of gas infection, to unwarranted

delay in the institution of surgical measures. The chapter on transfusion of blood and serum, written, it is explained, for the "trained but not necessarily highly experienced" man, is incredibly confusing; the apparatus is too complicated and the glass bead filter has been abandoned in this country because it is inefficient. The diagram on page 47 shows unfiltered air bubbling through stored blood.

Whilst it is unavoidable that overlapping should occur in a volume by various authors, there is less excuse for the conflicting statements which appear in regard to the value of chemotherapy. The chapter on chemotherapy is written by a consultant physician to a manufacturing firm who states (page 98) that "the organisms upon which the sulphonamides have a specific action are: β hæmolytic streptococci, meningococci, gonococci and pneumococci. In addition, certain compounds have *some* action upon *strains* of Escherichia coli, staphylococci, anaerobic bacilli, B. pyocyaneus, B. proteus and some varieties of low grade streptococci, Brucella, B. anthracis, S. actinomyces and B. tetani." Although the italics are ours, the list is formidable. He then emphasizes that only one strain of streptococcus, namely, β hæmolytic streptococcus, is controlled satisfactorily by sulphonamides. In the succeeding pages, unfortunately, we read that as regards anaerobic bacilli "insufficient experience has yet been obtained", as regards staphylococci "such infections may occasionally be influenced", and as regards tetanus "there is evidence that sulphonamides can be used with hope of success even without injecting anti-toxin, but this with other treatment must be given". This is all very unsatisfactory and not worthy of inclusion. The same contributor states quite definitely that the local use of sulphonamides in wounds is irrational, quite apart from their almost complete lack of action in the presence of pus, and that there is no clinical evidence available so far as to whether the local application of sulphonamides to excised wounds has been a factor in the improved results of modern surgical methods. He does not mention the prevention of infection with sulphonamides. Fleming (page 149) states that the sulphonamide drugs cannot be regarded as efficient antiseptics in septic wounds. Yet in the chapter on gas gangrene we read that "evidence is growing that sulphonamide *or* sulphapyridine [italics ours] given by mouth prevents both streptococcal and gas gangrene infection", and that the direct application of sulphonamide powder to wounds after excision gives "promising results". On the other hand, H. H. Sampson in his chapter on the local treatment of recent wounds states (page 76) that it is too early to give an opinion on the value of sulphonamide in the prevention of infection.

Criticism has been directed to these chapters on transfusion, gas gangrene and chemotherapy because of their extreme importance at the present time. The guidance to the younger surgeons, called upon to do military surgery, contained in the remaining chapters leaves little to be desired, and the chapters on shock, burns and the local treatment of recent and infected wounds make the book invaluable to all who may be called upon to deal with wounds. We look forward with interest to the succeeding volumes.

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**Handbook of Anæsthetics** (formerly Ross and Fairlie). Revised by R. J. MINNITT, M.D., D.A.; Fifth Edition; 1940. Edinburgh: E. and S. Livingstone. Crown 8vo, pp. 378, with illustrations. Price: 12s. 6d. net.

THE names of Ross and Fairlie should need no introduction to anyone interested in the study of anæsthesia, and R. J. Minnitt's revision of their handbook is a valuable contribution to the science. This instructive book has always been a guide to the student and a work of reference for the experienced anæsthetist. The new edition is welcome because it includes new methods and new apparatus.

Perhaps the greatest advances in modern anæsthesia have been the introduction of the carbon dioxide absorption technique, and the discovery of the new gas anæsthetic cyclopropane. The contribution by Waters of the "to and fro" absorber, the first really efficient one, made the method practicable. The value of the absorption technique is now only too well evident and is seen to advantage in the closed circuit apparatus of Connell, Heidbrink and Forreger. Cyclopropane is still in the experimental stage in this country, and will always be treated with a great deal of respect because of its inflammability, especially in association with mixtures of nitrous oxide and oxygen.

The chapter on the therapeutic use of oxygen, helium and carbon dioxide is especially interesting because of the aid these gases have been in the treatment of post-operative complications. It also introduces to us the importance of helium as a supporting gas for anæsthetic and therapeutic practice.

Spinal anæsthesia might, perhaps, have been given more prominence. Since the introduction of "Percaine" and the work of Howard Jones, spinal anæsthesia in

selected cases has undoubtedly proved to be one of the most satisfactory methods that the anæsthetist has at his command. In the hands of the experienced very few of the complications and after-effects, of which a great deal has been written, are seen; and when they do appear, they are often the result of faulty technique and lack of experience in the selection of cases.

The book is well illustrated and is sufficiently complete for the needs of the student as well as the practitioner.

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**The Anatomy of the Female Pelvis.** By F. A. MAGUIRE, C.M.G., D.S.O., V.D., M.D., Ch.M., F.R.C.S., F.R.A.C.S., F.R.C.O.G.; Third Edition; 1940. Australia: Angus and Robertson. Demy 8vo, pp. 172, with illustrations. Price: 10s. 6d. net.

THIS systematic description of the anatomy of the pelvic viscera should be of the greatest value to the student commencing the practical side of gynæcological teaching. Dr. Maguire has the happy knack of making his subject the study of the living rather than of the cadaver, as the practising gynæcologist will find on perusing this little volume. Such practical points as the potential dangers to the ureters during operative procedures, and the difficulty in definition of the so-called cardinal or Machenrodt's ligaments are clearly brought out. The sections on applied anatomy and physical examination are exceptionally good, and should be the pattern by which students are educated in their teaching clinics towards the higher flights of accurate diagnosis. As in that classical work "The Anatomy of the Human Skeleton" (Frazer), stress is laid on a sound knowledge of the bony, ligamentous and muscular structure of the pelvis, and appreciation of these points is greatly helped by clear illustrations.

We consider this volume a worthy addition to the ranks of Australian medical literature.

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**The Injured Back and its Treatment.** Edited by J. D. ELLIS, M.D.; 1940. Illinois: C. C. Thomas. London: Baillière, Tindall and Cox. Super royal 8vo, pp. 377, with 156 illustrations. Price: $5.50 net.

THE nine chapters in this book have been written by various eminent authorities. The first is Sir Arthur Keith's "Man's Posture"', a philosophical contribution with some practical observations; he thinks that spondylolisthesis is always due to injury and knows of no evidence suggesting maldevelopment as the cause. Eight contributors include neurosurgeons, orthopædic surgeons and a professor of medicine; the last-mentioned quotes Lembrights, who found that 10% of patients with chronic disease had backache. There is a long chapter on the routine examination of the injured back, and this, whilst it may confuse the tiro, must impress him with the difficulty of making anything like an accurate diagnosis of the cause of the common pain in the back. Other chapters deal with fractures, neurosurgical aspects of back injuries, the relationship of trauma to diseases of the spine, and a chapter on the treatment of minor injuries. In the latter chapter is included a reproduction of four safety instruction cards and posters published by the National Safety Council of the United States of America. These might well, in fact ought to, be posted in factories and places of manual labour employment in this country. A sprained back is caused by wrong lifting: "You may be as strong as an ox, but be careful what you lift", "Always bend your legs on lifting", and "Lift with your legs and not your back" are some of the slogans which are accompanied by dramatic illustrations of the right and wrong ways of lifting. This is a valuable book.

## Editorial Notices.

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